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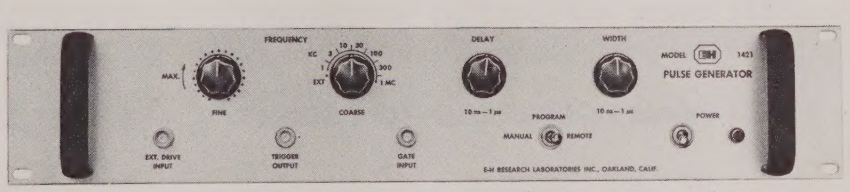
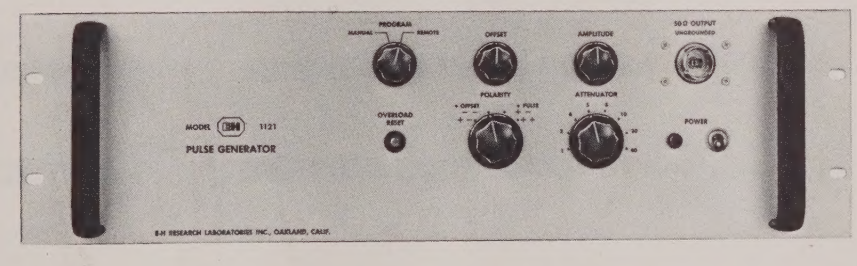
MODEL 1421 TIMING UNIT
AND
MODEL 1121 PULSE DRIVER





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SUMMARY PULSE GENERATORS

E-H PULSE ACCESSORIES

SECTION 1

GENERAL DESCRIPTION

1-1 INTRODUCTION

The Model 1421 Timing Unit is designed to provide the timing information to drive the Model 1121. The Model 1421, therefore, determines the pulse repetition rate and the pulse width of the Model 1121. The Model 1421 also supplies a trigger output pulse for synchronization of other equipment, such as oscilloscopes or additional pulse generators. In conjunction with the trigger output, the Model 1421 provides variable delay time between the trigger pulse and the Model 1121 output pulse. The Model 1421 specifically features calibrated, front panel width and delay controls as well as optional remote control of these functions.

The Model 1121 Pulse Driver is designed to operate in conjunction with the Model 1421 Timing Unit. The Model 1121 is a programmable pulse output unit that supplies a 50 volt pulse of either polarity with a 2 nanosecond risetime. In addition, it provides ± 5 volt baseline offset bias. It is designed to be externally driven at any pulse repetition rate up to 1 megacycle. It specifically features calibrated, front panel amplitude and baseline offset controls as well as optional remote control of both pulse and baseline offset amplitude and polarity.

1-2 SYNOPSIS OF OPERATION

a. MODEL 1421 TIMING UNIT - This instrument is designed to drive the Model 1121 Pulse Driver Unit. The Model 1121, therefore, serves as a voltage and current amplifier for the input pulse. The pulse repetition rate and pulse width determines the repetition rate and the width of the output from the Model 1121 Pulse Driver. Repetition rate may be determined in one of two ways; the Model 1421 has an internal clock circuit, or it may be also externally driven. Pulse repetition rate may be further modified by the use of a gate circuit that operates in conjunction with the clock. A gate signal will disable the clock multivibrator until that signal is removed.

The output of the clock multivibrator drives both the trigger circuit and the delay circuit. The output of the trigger circuit is coupled to the trigger output connector, and this signal is used both for synchronizing the Model 1421/1121 with other units.

Delay time is determined by the charging time of a constant current into a capacitor. At the end of the delay time--when the delay capacitor charges to a certain level--the delay circuit will switch to its

other stable state and remain there until the signal from the clock generator, or clock multivibrator, turns it off. The output from the delay circuit turns on both the width circuit and the output circuit. At the end of the width time, the output turns off again.

b. MODEL 1121 PULSE DRIVER - This unit is designed to be driven by the output pulse of the Model 1421. Model 1121 is basically a series of cascaded, overdriven Class C amplifiers. The main function of the Model 1121 Pulse Generator is to provide an output pulse at the same frequency and pulse width as the Model 1421 input drive pulse. The Model 1121 may be driven at rates up to 1 megacycle. An inverting transformer provides either positive or negative output pulses. An additional current supply circuit at the output provides up to 5 volts positive or negative baseline offset current.

As an option, amplitude, attenuation, pulse polarity, offset polarity, and offset current may all be externally controlled with the use of binary-coded decimal input signals.

1-3 SPECIFICATIONS - MODEL 1421 TIMING UNIT

PULSE REPETITION FREQUENCY - 1 kilocycle to 1 megacycle with internal clock. Zero to 1 megacycle from external clock. The internal clock is continuously variable by the COARSE FREQUENCY selector switch (1/3/10/30/100/300 kilocycles, 1 megacycle), and vernier control.

PULSE WIDTH - 10 nanoseconds to 1 microsecond. Continuously variable with a graduated 10-turn potentiometer. When equipped with optional remote control feature, may be externally controlled with binary-coded decimal signals over the same range. Accuracy is ± 3 nanoseconds, ± 5% of reading.

PULSE DELAY - 10 nanoseconds to 1 microsecond. Continuously variable with a graduated 10-turn potentiometer. When equipped with optional remote control feature, may be externally controlled with binary-coded decimal signals over the same range. Accuracy is ± 3 nanoseconds, ± 5% of reading.

EXTERNAL DRIVE - Positive 1.5 volt required, +15 volt maximum. $Z_{in} \cong 200$ ohms. Maximum risetime for external drive pulse ≅ 0.1 microsecond per volt. The external drive pulse width must exceed the sum of delay time plus width time of the Model 1421.

TRIGGER OUTPUT - Positive 1.5 volts into 50 ohms, 3 volts open circuit.

SYNCHRONOUS GATE - Negative 2 volts required to block pulse train, -15 volts maximum. When the gating signal is removed, it re-initiates the pulse train; thus synchronizing the output pulse with the gate signal. $Z_{in} \cong 300$ ohms.

DIMENSIONS - Rack Mount: 3-1/2" high, 19" wide, 17" deep.

POWER REQUIREMENTS: 105/125 vac; 0.3 amperes; 50/60 cycles. May be easily converted to 220 volt operation.

1-4 SPECIFICATIONS - MODEL 1121 PULSE DRIVER

OUTPUT PULSE AMPLITUDE - Positive or negative 0.5 volts to 50 volts into 50Ω; Continuously variable by step attenuator and amplitude control. Amplitude control is with a graduated 10-turn potentiometer; accuracy is 5% of reading from 20 to 50 volts, on the X1 attenuator position. An internal step attenuator provides up to 40:1 attenuation; accuracy is ±2%.

DC OFFSET - ±5 volts dc baseline offset, continuously variable with a graduated 10-turn potentiometer. Accuracy is ±100 millivolts, ±5% of reading. Baseline offset is attenuated by the internal attenuator.

WAVEFORM - Pulse top distortion is less than 5% peak-to-peak, including overshoot, droop, ringing, and all pulse top anomalies for all amplitude conditions.

RISE AND FALL TIME - (10% to 90%) - Risetime is less than 2 nanoseconds and falltime is less than 4 nanoseconds at maximum amplitude. Faster rise and fall times are possible at reduced amplitude.

DUTY FACTOR - 10% maximum.

REMOTE PROGRAMMING OPTIONS - The Model 1121 has provisions for the E-H Model 930 Digital to Analog Converters. Each of two converters provides 1000-count binary-coded-decimal control for remote programming of the pulse amplitude and dc offset. The internal attenuator and polarity controls may also be remotely programmed. Programming range for amplitude control is ±20 volts to ±50 volts; accuracy is ±5% of reading from 20 to 50 volts, on the X1 attenuator position. With internal attenuator, the Model 1121 may be remotely programmed for variable pulse amplitude control from ±0.5 volts to ±50 volts.

Programming range for offset control is ±5 volts; accuracy is ±100 millivolts ±5% of reading. Offset polarity is also programmable. Baseline offset is attenuated by the internal attenuator.

DIMENSIONS - Rack Mount: 5-1/4" high, 19" wide, 17" deep.

INPUT DRIVE REQUIREMENTS - Positive 5 volts pulse; risetime ≅ 5 nanoseconds.

WEIGHT - Approximately 40 lbs; 46 lbs packed.

POWER REQUIREMENTS - 105/125 vac; 2 amperes; 50/60 cycles. May be easily converted to 220 volt operation.

SECTION 2

OPERATING INFORMATION

2-1 UNPACKING

Immediately upon receipt, carefully unpack and inspect the instruments for possible damage received during transit. If either of the instruments fail to operate properly, or are damaged in any way, a claim must be filed with the carrier.

2-2 234 VOLT OPERATION

The Model 1121 and the Model 1421 are both supplied with internal transformer-powered supplies. The primary windings are wired for 117 volt power line use. For use with 234 volt power line, the transformer primaries must be rewired. Refer to the Power Supply Schematic drawings in this manual for proper connections.

2-3 TERMINATING IMPEDANCE

The Model 1121 output appears to the external load as a voltage source. Although the actual output impedance is not 50 ohms, the instrument is designed to operate into a 50 ohm resistive load. Operation into any other impedance will cause some pulse distortion. Loads with appreciable capacitive or inductive components will have a marked effect on the leading and trailing edges of the pulse.

NOTE

The Model 1121 has automatic internal overload protection; however, the instrument should always be operated with a 50 ohm resistive load connected to the output terminals.

2-4 CABLES, CONNECTORS AND ATTENUATORS

The fast risetime of the Model 1121 output pulse has appreciable frequency components up to 200 Mc. If any of these high frequency

components are attenuated through the use of connectors, cables or attenuators that do not have a flat frequency response in excess of these frequencies, degradation of the pulse risetime will result. Mismatch effects can also degrade the pulse waveform. Consequently, consideration and care must be taken to preserve the quality of the Model 1121 pulse output, when coupling it to the system or device under test. Some precautions to observe in coupling the pulse outputs of this instrument are:

a. The average output power of the Model 1121 can go as high as 5 watts; therefore, when using external attenuators, always use attenuators capable of dissipating 5 watts or more.

b. Always terminate the output of the Model 1121 in a 50 ohm resistive load.

c. If the input impedance of the device or system under test is other than 50 ohms, use an impedance-matching device so that mismatch effects will not degrade the pulse waveform.

d. Make sure that all connectors, attenuators, and cables are of proper impedance and have a flat frequency response in excess of 200 megacycles. Use only high quality, 50 ohm coaxial cable such as RG213/U. For best results, use short cable since long cable tends to attenuate the high frequency components of the pulse. General Radio (GR) 874 Series, Coaxial Connectors are recommended for use with the Model 1121 OUTPUT connector.

2-5 OPERATING CONTROLS

Operating controls, indicators, and connectors are listed in Tables 2-1 and 2-2.

Table 2-1 Model 1421 Operating Controls, Indicators and Connectors

CONTROL	OPERATION
POWER	With the line cord connected to a 117 VAC, 50/60 cps, power source, and the power switch set to its ON position, the power indicator lamp will light.
FREQUENCY COARSE	The COARSE FREQUENCY selector switch selects pulse repetition rate as determined by an internal clock from 1 kilocycle to 1 megacycle, or an external drive input from zero to 1 megacycle. Pulse

CONTROL	OPERATION
	repetition ranges are (1/3/10/30/100/300 kilocycles and 1 megacycle), and EXT. drive.
FINE	The FINE frequency control provides a continuous adjustment of any pulse repetition rate in a given range with overlap to adjacent ranges.
DELAY	The DELAY control is a 10-turn, helical potentiometer. It provides continuous time delay control between the trigger output pulse and the output pulse of the Model 1121. This control is graduated and accurate to 3 nanoseconds, ± 5% of reading. The delay time range is variable from 10 nanoseconds to 1 microsecond. NOTE: Delay time should be less than 50% of the pulse period.
WIDTH	The WIDTH control is a 10-turn helical potentiometer. It provides continuous output pulse width control of the Model 1121. This control is graduated and accurate to 3 nanoseconds ± 5% of reading. Pulse width range is variable from 10 nanoseconds to 1 microsecond. NOTE: Pulse width should be less than 50% of the pulse period.
PROGRAM Manual:	When the PROGRAM switch is set to the MANUAL position, the front panel controls operate the control functions as discussed above.
Remote:	The REMOTE function disables the front panel DELAY and WIDTH controls. It permits remote programming operation with the E-H Model 930 Digital to Analog Converter, which is a 1000 count binary-coded decimal circuit. For detailed operating instructions, see Section 2-6.

CONTROL	OPERATION
POWER INDICATOR	This indicator lights when the instrument AC power switch is turned ON.
OUTPUT CONNECTOR	The OUTPUT connector is found on the rear panel and is labeled J103. It should be connected to the rear panel INPUT connector of the Model 1121. Use the cable supplied with the instrument, because the length of this cable affects the delay time calibration.
TRIGGER OUTPUT CONNECTOR	The TRIGGER OUTPUT connector provides a positive 1.5 volt signal into a 50 ohm load. Maximum trigger signal is +3 volts into an open circuit. $Z_{out} \cong 50\Omega$. The trigger output pulse may be used to synchronize or trigger an oscilloscope, another pulse generator or other devices. Type BNC connector.
GATE INPUT CONNECTOR	The GATE INPUT connector permits a negative pulse or d-c level (from -2 volts minimum to -15 volts maximum) to inhibit the clock circuit. Since the positive-going, or trailing edge of the gate signal initiates the output pulse train, synchronous operation of the pulse generator is possible. $Z_{in} \cong 200\,\Omega$.
EXT. DRIVE INPUT CONNECTOR	The EXTERNAL DRIVE INPUT permits an externally supplied pulse train (amplitude from +1.5 to +15 volts) at a pulse repetition rate from zero to 1 megacycle, to drive the Model 1421. Maximum external drive input pulse risetime is 0.1 ns/V. $Z_{in} \cong 50\Omega$. Type BNC connector.

Table 2-2 E-H Model 1121 Operating Controls, Indicators, and Connectors

CONTROL	OPERATION
POWER	With the line cord connected to a 115 VAC, 50/60 cps, power source, and the POWER switch set to the ON position, the POWER indicator lamp will light and the cooling fan will be energized.
AMPLITUDE	The AMPLITUDE control is a graduated 10-turn potentiometer. Its function is to provide manual control of the output pulse amplitude. With the ATTENUATOR switch set to 1, the AMPLITUDE control will vary the output pulse amplitude from

CONTROL	OPERATION
	less than ±20 volts to ±50 volts.
ATTENUATOR	The ATTENUATOR switch selects either a fixed resistive attenuation or a straight-through connection. Output pulse attenuation ratios are: 1:1, 2:1, 4:1, 5:1, 8:1, 10:1, 20:1, and 40:1.
POLARITY	The POLARITY switch selects both the output pulse polarity and the d-c baseline offset polarity. This control is a 4-position rotary switch which permits selection of any one of four combinations of pulse polarity and d-c offset baseline polarity. The red panel markings refer to the baseline offset polarity, and the blue panel markings refer to the output pulse polarity.
OFFSET	The OFFSET control is a graduated 10-turn potentiometer which determines the offset current available at the OUTPUT connector. Baseline offset current is variable from zero to ±100 milliamperes (across a 50-ohm load), depending on the setting of the POLARITY selector switch and the OFFSET potentiometer.
PROGRAM Manual:	When the PROGRAM selector switch is set to the MANUAL position, the front panel controls operate the control functions as discussed above .
Remote:	The REMOTE function disables the front panel AMPLITUDE, ATTENUATOR and OFFSET controls. It permits remote programming operation with the E-H Model 930 Digital to Analog Converter, which is a 1000 count binary-coded decimal circuit. For detailed operating instructions, see Section 2-6.
POWER INDICATOR	The POWER indicator lamp will light when the POWER switch is turned to the ON position.
OVERLOAD INDICATOR	The OVERLOAD indicator is a combination switch and lamp unit. If the output pulse duty factor exceeds 10%, the overload circuit will turn off the power supply and light the OVERLOAD

CONTROL	OPERATION
	indicator lamp. To restore the circuit to normal operation, correct the overload condition, and then depress the combination lamp and switch unit. The OVERLOAD lamp normally lights when the instrument is turned on. Allow the tubes to warm up approximately 30 seconds before depressing the switch.
INPUT CONNECTOR	The BNC INPUT connector (J101) is located on the rear panel. The input should be connected to the BNC OUTPUT connector of the Model 1421. The Model 1121 input pulse drive requirement is for a 6 volt positive pulse.
OUTPUT CONNECTOR	The OUTPUT connector is located on the front panel. It is a GR (General Radio) 874 connector. For best results, use short lengths of high quality 50 ohm coaxial cable, such as RG 213/U. Terminate the output in a 50 ohm resistive load.

2-6 OPTIONAL REMOTE CONTROL OPERATION (GENERAL)

a. Remove the E-H Model 1421 and/or Model 1121 dust covers, and insert the Digital to Analog Converter circuit boards in the sockets. The circuit boards should fit such that the circuit components are facing up.

b. Connect the inter-connect cable to the Amphenol mating connectors J102 on the Model 1121 and J103 on the Model 1421.

c. The remote control input connector is located on the rear panel of the Model 1421, and is designated J102. The proper pin connections for the Winchester connector (J102) are indicated on the Model 1421 Master Schematic (Drawing No. D-11657).

d. Remote control functions on Model 1421 and/or Model 1121 may be accomplished by activating the proper lines on the Winchester connector. The logic levels are +10v "true" and 0v "false". These levels are available at plug J102 so that remote control lines may be activated by closing switches (active or passive) to effectively tie +10v to the appropriate control lines. These lines and the function they control are shown on the Model 1421 and 1121 Master Schematic Diagrams. Control line input impedance is greater than 10K ohms.

e. To adjust the Digital to Analog Converters, a 50 ohm "scale factor" adjust trimpot and a 10K ohm "zero" adjust trimpot are mounted on the converter printed circuit board. The "scale factor" adjust controls the maximum parameter range and the "zero" adjust controls the minimum parameter range. These minimums and maximums are shown in the following table.

Pulse Parameter Input Counts are:

Function	Min. Count	Max. Count
Delay	10 = 10 ns	1000 = 1000 ns
Width	10 = 10 ns	1000 = 1000 ns
Amplitude	200 = 20 v	500 = 50 v
Offset	0 = 0 v	500 = 5 v

NOTE

Programming outside the ranges indicated in the above table will not damage the instruments, but the accuracy specifications will no longer apply.

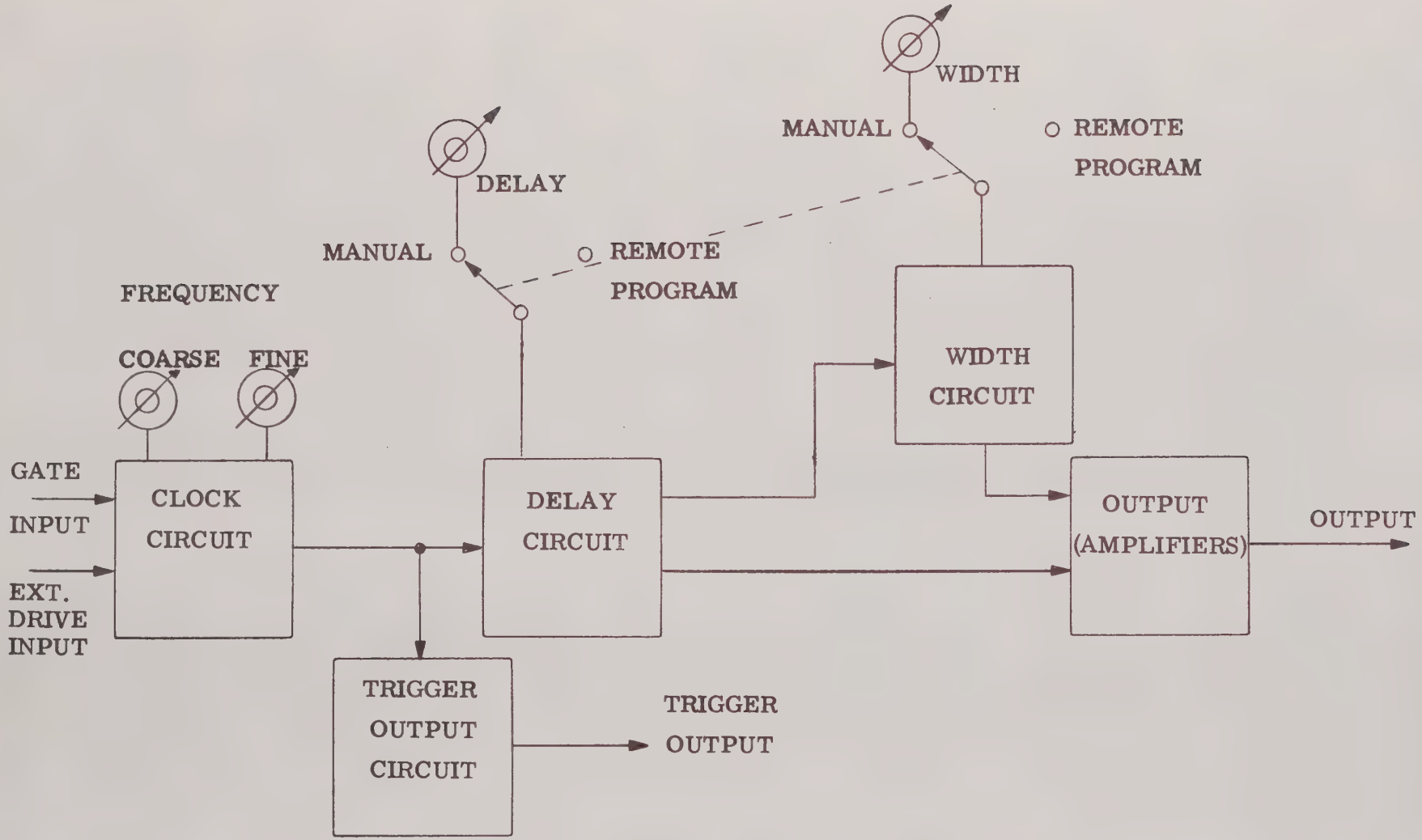


Figure 3-1 MODEL 1421 PULSE GENERATOR

BLOCK DIAGRAM

SECTION 3

MODEL 1421
THEORY OF OPERATION

3-1 GENERAL DESCRIPTION

(Refer to Model 1421 Block Diagram, Figure 3-1)

The Model 1421 consists of a clock circuit, a delay generator circuit, a width circuit, and a trigger circuit, as shown in the Block Diagram (Figure 3-1). The function of the Model 1421 Pulse Generator is to provide timing information to drive the Model 1121. The timing information consists of the pulse repetition frequency, delay time, and pulse width. Therefore, the Model 1421 Timing Unit is logically divided into: Clock Circuit, Delay Circuit, Width Circuit, and the Auxiliary Functions. The Auxiliary Functions are the gate, external drive, and trigger circuits.

The clock is an emitter-coupled astable multivibrator. It determines the pulse repetition frequency. Its period is determined by the emitter coupling capacitor, which is selected and switched into the circuit by the COARSE FREQUENCY selector switch. The output of the clock multivibrator is amplified and fed to both the trigger and to the delay circuits.

The delay circuit compares a ramp voltage to a d-c voltage level and provides an output signal when the ramp voltage exceeds the d-c voltage level. The comparing circuit is a current mode switch. One input is the ramp, which is initiated by the leading edge of the clock pulse. The ramp is formed by charging a capacitor with a constant current. The second input to the current mode switch is a d-c level which is determined either by the front panel DELAY control or the optional remote control circuitry.

The width circuit is identical to the delay circuit with the exception that the voltage ramp is initiated by the leading edge of the delay circuit output pulse.

There are two cascaded, current-mode switch circuits following the width circuit. These two circuits are dual transistor, emitter-coupled, nonsaturating (current mode) switch circuits. The switch circuits provide voltage amplification for the output of the width circuit. Following the second switch circuit is an emitter follower output stage. Its output is a positive 6 volt pulse that drives the Model 1121.

The GATE INPUT, EXT. DRIVE INPUT and TRIGGER OUTPUT may be considered auxiliary functions. The gate circuit disables the clock multivibrator for the duration of the gating signal. When the GATE INPUT signal is removed, the clock multivibrator operates normally. The result is a series of pulse bursts. The gate circuit operates by blocking the current to one of the clock multivibrator transistors. Each gate pulse

resets the clock-multivibrator circuit to the same original condition, which minimizes jitter or differences in pulse position of the first pulse in each burst.

The external drive circuit permits the Model 1421 to be driven at some frequency determined by an external signal source. When the COARSE FREQUENCY switch is set to EXT., the clock multivibrator is disabled. Each external drive pulse turns the clock multivibrator on again for the duration of the drive pulse. The Model 1421 then generates one output pulse for each external drive pulse. The width of the external drive pulse must be as great or greater than the delay time plus width time of the Model 1421.

The TRIGGER output provides a pulse which precedes the output pulse by the delay time. The trigger pulse is useful for synchronizing or triggering an oscilloscope or another pulse generator. The signal that drives the TRIGGER OUTPUT circuit also drives the delay circuit; thus, there is one trigger pulse for each output pulse.

3-2 MASTER SCHEMATIC

(Refer to Drawing Number D-11657)

Principle components mounted on the pulse-generator chassis are the timing circuit board, power supply, and front-panel controls and connectors. Portions of various circuits, such as resistors, capacitors, and switches are also located on the chassis, along with inter-connecting wiring for power and signal distribution. An AC power receptacle and fuseholder are located on the rear panel. A removable cover permits ready access to the interior of the instrument.

3-3 CLOCK CIRCUIT

(Refer to Drawing Number D-11656)

Pulse repetition frequency is determined by an emitter-coupled, astable multivibrator, Q2 and Q3. The period of the multivibrator is determined by selecting the coupling capacitors (C201 through C218), in sequence, by the front-panel COARSE FREQUENCY selector switch. The collectors of the multivibrator transistors are clamped by CR1 and CR3 to the emitter voltage of Q1. The collectors of Q2 and Q3 are cross-coupled to the bases of Q3 and Q2, respectively, with matched zener diodes. The collector clamp diodes (CR2 and CR4) limit the voltage swing of the emitters. Consequently, the time required to charge the emitter-coupling capacitor is controlled by the emitter voltage of Q1. By changing the clamp voltage, Q1 serves as a frequency vernier control.

During normal free-running operation, the control transistor Q4 is saturated and does not affect the multivibrator operation. The output of the

clock multivibrator is a square wave that is coupled to a current-mode (nonsaturating) transistor switch circuit. This switch amplifies and isolates the clock signal from subsequent circuits.

3-4 DELAY CIRCUIT

(Refer to Drawing Number D-11656)

Delay is accomplished by charging a timing capacitor with a constant current source and comparing the capacitor voltage to a reference voltage.

The timing capacitor is C5. Its constant current source is the collector current of Q7. The current is alternately shunted to ground through Q8 or allowed to flow into C5, so that voltage across C5 is alternately at ground or rises to some positive value. The clock signal comes from the collector of Q5 and goes into Q8. Q8 is either turned on or off by that clock signal. The negative-going pulse from Q5 is clamped by CR6 so that it can only go approximately one-half volt below ground. The positive-going pulse then turns on Q8 and can only go up to approximately 0.7 volts above ground. The function of CR8 is to keep transistor Q8 from going into saturation. The desired time delay is adjusted by changing the voltage drop across R25. The input is at terminal L, and it is controlled by either the front-panel DELAY control, or the remote program circuits. The voltage level at R25 is set between approximately zero volts and +5 volts. Voltages over this range correspond to a time delay between 10 nanoseconds to 1 microsecond.

Assuming that a negative signal from Q5 has just turned off Q8, the voltage at its collector (which is common to the base of Q9) starts to rise in a positive direction. As soon as the voltage at the base of Q9 becomes more positive than the voltage at the base of Q10, Q9 turns on and Q10 turns off. This signal is amplified by another current-mode switch circuit, Q11 and Q12. The function of diodes CR11 and CR12 is to clamp the collector voltage swing so that the total swing is only 0.75 volts, as seen at the collectors of Q9 and Q10. Q28 provides a current source for Q9 and Q10. The output of Q11 drives the base of Q19, and turns on the output amplifier.

3-5 WIDTH CIRCUIT

(Refer to Drawing Number D-11656)

When Q11 turns on, Q12 turns off, and this drives the width circuit (Q14, 15, and 16). The delay and width circuits are essentially identical. The negative signal from Q12 turns Q14 off, and the timing function is performed again. Q14 turns on and off, shorting or opening the current source. The timing capacitor is C9, and the time period generated

corresponds to the output pulse width. The output is taken from Q17 and Q18. The collector signal from Q18 is tied to the collector of Q11, so that the output from the second timing circuit (the width circuit) is added to the output of the first timing circuit (the delay circuit). The pulse at the base of Q19 is an exact replica of the pulse desired at the final output.

3-6 AMPLIFIER CIRCUIT

(Refer to Drawing Number D-11656)

The function of Q19 and Q20, and Q21 and Q22, is to amplify the pulse. Q23 is an emitter follower to provide a low impedance output so that the pulse can be sent to the Model 1121.

3-7 AUXILIARY FUNCTIONS

(Refer to Drawing Number D-11656)

The gate input, external drive, and trigger output connectors are considered auxiliary functions.

a. EXTERNAL DRIVE - The external drive circuit provides a means by which the Model 1421 may be driven at some frequency determined by an external signal source. When the coarse frequency selector switch is set to EXT., the entire clock circuit is changed from astable to a bistable operation. The clock circuit provides one pulse, which is coupled to the delay circuit, for each external drive pulse. During the normal free-running operation, control transistor Q24 is saturated and does not affect the operation of the clock multivibrator. When the coarse frequency selector switch is set EXT., the biasing resistor R46 is switched from the +15 volt bus, and Q24 is cut off, which opens the ground return to Q3. and disables the clock multivibrator. Current through R47 and CR20 and clamps the cathode of CR21 at the cathode potential of CR20. Current through R49 and CR21 places the junction of CR21 and 22 near ground potential. Current through CR22 and R52 biases Q4 slightly negative with respect to ground by the forward voltage drop across CR22. A positive external drive signal will develop sufficient potential across R47 to back-bias CR21. The base of Q4 is no longer clamped, so that current through R49 can bring the base of Q24 positive. Tunnel diode CR25 switches and drives the base of Q24 positive--very much faster than the external drive signal. Q24 turns on and remains on for the duration of the external drive signal.

For external drive, the emitter of Q4 is coupled to the emitter of Q2 through clamp diode CR5. This clamp voltage is adjusted by R102 to prevent the clock multivibrator from free-running during external drive mode operation.

b. GATE - The gate circuit interrupts the pulse train as a function of the gate input signal. A negative gate signal disables the clock multivibrator. When the signal is removed, the clock multivibrator will continue to operation normally.

The gate signal is coupled to the junction of CR21 and CR22 through the GATE INPUT CR23 and CR24. The negative signal back-biases CR22, which places a negative bias on the base of Q24, and blocks the emitter for Q3. Thus, the gate disables the clock multivibrator in the same manner as the external drive circuit. When the negative gate input signal is removed, CR22 becomes forward-biased again, the base of Q24 goes positive, and the tunnel diode CR25 will switch to provide a fast positive step at the base of Q24 and turn the clock multivibrator on. Each time the gate signal is removed, the clock circuit is in the same condition, so that this minimizes jitter in the position of the first pulse following each gate signal.

c. TRIGGER CIRCUIT - The trigger multivibrator is an emitter-coupled monostable multivibrator with a fixed period.

The positive signal at the collector of Q6 is differentiated by L1 and coupled to the base of Q25. Q25, which is normally on, turns off and Q26 turns on. The multivibrator output is coupled to the base of emitter follower Q27, and its output is the trigger pulse.

3-8 DIGITAL TO ANALOG CONVERTER SCHEMATIC

(Refer to Drawing Number D-11502)

The Digital to Analog Converter is a three-decade, binary-coded, control circuit. It functions as a remote control unit for the Model 1421 and Model 1121 Pulse Generators.

There are three sets of four parallel input lines. In each set, the lines are in 1, 2, 4, 8 binary-coded sequence. The entire group of 12 input lines therefore permit a 3-decade binary input count. The converter output is variable, depending upon the digital input count, where the input to each line is either zero or +10 volts.

The converter acts as a current source; the output current varies from zero to 10 milliamperes in 10μA increments. The output current drives the appropriate control circuitry in both instruments.

The Digital to Analog Converter circuit is composed of a parallel combination of 12 individual switch circuits--one for each input line. Each circuit is roughly equivalent to a resistor and switch in series. The converter output current is the sum of the currents through the closed switch circuits.

3-9 POWER SUPPLY SCHEMATIC

(Refer to Drawing No. D-11655)

TRANSFORMER, RECTIFIER, AND FILTER CIRCUITS

Power transformer T101 is factory-wired for service with 117 VAC power lines. For 234 VAC service, the primary winding should be re-connected in series as indicated on the Power Supply Schematic Diagram.

The power transformer T101 has one secondary winding. Its output is rectified by bridge circuit CR101 through CR104, filtered by capacitors C101 and C102, and then regulated at +15 volts, +10 volts, and -10 volts with respect to chassis ground.

REGULATORS - The power supply has three series regulator circuits: +15 volts with respect to chassis ground, -10 volts with respect to chassis ground, and +10 volts with respect to chassis ground.

In the +15 volt regulator, Q101 is the pass element. It is driven by the emitter of Q1, which is driven by the collector of Q2. Q2 and Q3 form an emitter-coupled differential amplifier circuit. The base of Q2 is held at its reference level by zener diode CR2. Any change in the regulator output voltage is sensed at the base of Q3, which is connected to the center arm of trimming potentiometer R10. R10 is in series with R9 and R11, and is the output voltage adjustment potentiometer.

The second regulator is the +10 volt regulator, and is similar to the +15 volt regulator. Q103 is the series pass element, and it is driven by the base of Q4. Q4 is driven by the differential amplifier Q5 and Q6. This is essentially the same circuit as the +15 volt regulator. R21 is the output voltage adjustment potentiometer for the +10 volt supply.

The third circuit is the -10 volt regulator. Q102 is the pass element, and its bias is controlled by Q7. Zener CR5 helps to decrease output ripple by reducing ripple at the base of Q102. R28, R29, and R30 reference the -10 volt supply to the +10 volt supply. Any change in the output voltage is sensed by the base of Q8, and amplified by Q7 to correct the bias of Q102.

WIDTH AND DELAY CONTROLS - Included on the Model 1421 power supply schematic are two transistor circuits, Q9 and Q10. When the PROGRAM switch is in the MANUAL position, these transistors drive the width and delay control circuits. Q9 is a variable current source for the delay circuit, and Q10 is a current source for the width circuit. Q9 and Q10 are controlled by 10-turn potentiometers, R211 and R209 respectively. The PROGRAM selector switch, in the REMOTE position, substitutes two E-H Model 930 Digital to Analog Converters for the current sources Q9 and Q10.

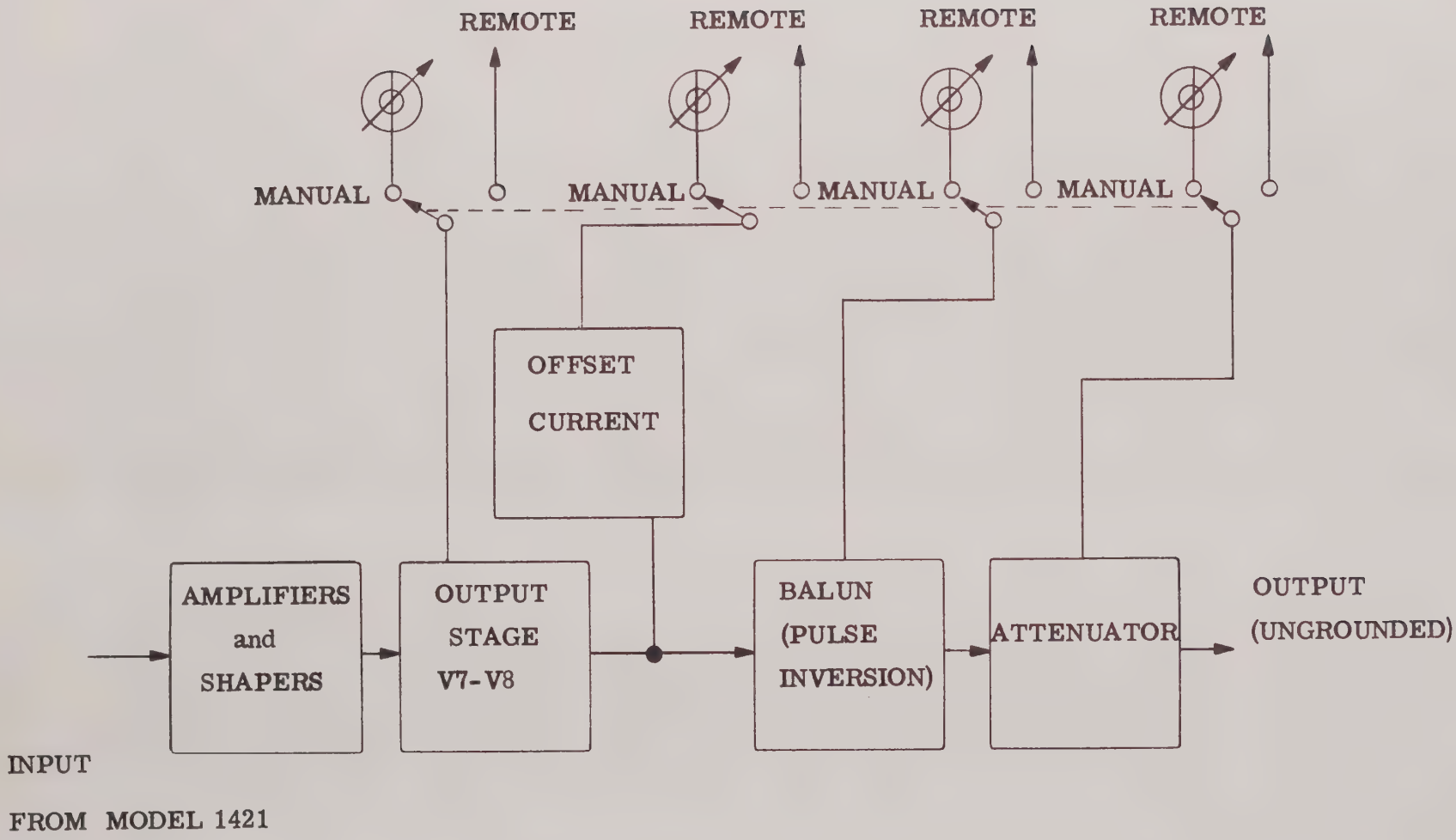


Figure 4-1 MODEL 1121 PULSE DRIVER

BLOCK DIAGRAM

SECTION 4

MODEL 1121
THEORY OF OPERATION

4-1 GENERAL

(Refer to the Model 1121 Block Diagram, Figure 4-1)

The first section of the Model 1121 is the input section, which consists of overdriven Class C amplifiers. The output stage, the second block, is a pair of overdriven Class C amplifiers connected in parallel. The output signal is coupled to a balun, which is used for pulse inversion. The inputs of the balun may also be supplied with up to 100 milliamperes current, either positive or negative. This current serves as a baseline offset bias, which will provide up to ±5 volts baseline offset voltage across the 50 ohm external load. The output of the balun is coupled to an attenuator which may be remotely controlled. The output of the Model 1121 Pulse Driver is a 50 volt pulse of either polarity, with a risetime of 2 nanoseconds.

4-2 MASTER SCHEMATIC

(Refer to Drawing Number D-11806)

Principle components mounted on the pulse generator chassis are the output circuit board, attenuator, power supply, and front-panel controls and connectors. Portions of various circuits, such as resistors, capacitors, and switches are also located on the chassis, along with interconnecting wiring for power and signal distribution. An AC power receptacle, fuseholder, and cooling fan are located on the rear panel. A removable cover permits ready access to the interior of the instrument.

4-3 AMPLIFIER AND SHAPER CIRCUITS

(Refer to Drawing Number D-11805)

Tubes V1 through V6 are transformer-coupled, Class C overdriven amplifiers. The pulse output from the Model 1421 Pulse Generator is successively amplified and shaped by these tubes until a risetime of 2 nanoseconds can be obtained at the output. The final two tubes in this circuit (V5 and V6) are connected in parallel. Tubes V1 and V2 are biased by the diodes CR1 and 2, which is between the chassis ground and the cathodes of V1 and V2 respectively. Emitter follower Q1 serves as a cathode bias voltage reference for tubes V3, 4, 5, and 6. The cathode current for each of these tubes is supplied by Q1. Q1 is biased by diodes CR3 and 4 and resistor R11.

4-4 OUTPUT STAGE

(Refer to Drawing Number D-11805)

The output of V5 and V6, the final tubes in the shaping chain, is transformer-coupled to the grids of the two output tubes, V7 and V8. The output tubes are overdriven Class C amplifiers. The amplitude of the output pulse is determined by the electrode potentials of V7 and V8. These potentials are derived from a -180 volt power supply which is varied from less than -40 volts to greater than -180 volts to achieve pulse amplitude control. At the output stage, the cathode current of V7 and V8 is supplied by transistor Q2. The plates of V7 and V8 are coupled to a floating ground, and the cathodes of V7 and V8 are held at the emitter potential of Q2, somewhere between the variable cathode supply and the floating ground potential.

4-5 BASELINE OFFSET

(Refer to Drawing Number D-11805)

Offset current is provided either by Q6 or by Q7. Offset current is variable in either case from zero to ± 100 ma. Polarity control voltage is either zero or +10 volts at connector pin 6 of connector No. XA203. If the input control voltage is zero, then current through R16, between the bases of Q5 and Q4 from the -20 volt bus, tends to hold Q5 off and Q4 on. When Q5 is turned off, there is no emitter current available for transistor Q3. Q3 remains off, which holds Q6 off. Under these conditions there is no positive offset available. Q4, however, is on, which supplies emitter current to Q2. The base voltage of Q2 is, in turn, controlled by the emitter voltage of Q1. In this way transistor Q1 can control the emitter voltage of Q2, which will, in turn, determine the collector current of Q7, which is negative offset current available for offset. With the control input voltage at +10 volts, the negative offset current supply source is turned off, and the positive source is turned on. In this case, the collector voltage of Q1 determines the base voltage of transistor Q3, which, in turn, drives transistor Q6. The collector current of Q6 is the positive offset current available at the output. Trimming potentiometer R1 is a zero adjustment, and trimming potentiometer R4 serves as a fine trim. Potentiometer R5 provides an adjustment so that the positive and negative offset currents will track each other. Input control current is supplied to pin No. 1 of XA203. This is available either from the offset remote program circuit or the 10-turn offset potentiometer R206. The input current, at this point, is the driving current for Q1.

4-6 POLARITY INVERSION

(Refer to Drawing Number D-11805)

Output pulse polarity is determined by a Reed Switch driven by relay coil L12. L12 is driven by the transistor circuitry which is shown on Printed Circuit

Board No. 11416 on the lower righthand corner of Drawing No. D-11805. Q1 and Q2 are the Reed control driving transistors. There are two possible inputs from S204, Deck A2. The inputs can be zero, for negative output pulses, or +10 volts, for positive output pulses. Zero input voltage will hold Q2 off which, in turn, will hold Q1 off. With Q1 off, there is no drive current available for L12, and the output pulses are negative. A +10 volt input from S204 will hold transistor Q2 on, which will, in turn, hold transistor Q1 on. This permits drive current to flow through L12 and hold the contact closed for positive output pulses.

The attenuator drive circuits are located below the polarity drive circuit and operate in the same way. There are three sets of two reed switches, which switch attenuation ratios of 2:1, 4:1, or 5:1, or any combination for a maximum of 40:1. For X1 attenuation, all inputs are zero. A +10 volt input at any one of the attenuator circuits, 1, 2, or 3 will switch the appropriate attenuator into the circuit.

4-7 ATTENUATOR SCHEMATIC

(Refer to Drawing Number D-11853)

The attenuator circuit is operated by switching three sets of reed switches into the output circuit. The attenuation ratios are 2:1, 4:1, and 5:1, or in any combination for a maximum of 40:1. The switching circuit operation is described in Section 4-6.

4-8 DIGITAL TO ANALOG CONVERTER SCHEMATIC

(Refer to Drawing Number D-11502)

For a discussion of the Digital to Analog circuit operation, refer to Section 3-8.

4-9 POWER SUPPLY SCHEMATIC

(Refer to Drawing No. D-11804)

The power supplies are composed of several functional units. The power transformer has several secondary windings, and, excluding filament supplies, each secondary usually has associated with it rectifier, filter, and regulator circuits. There is also an overload protection circuit.

Each regulator circuit also has several functional units. In the Model 1121, all the regulators are the series type. Each regulator has an output level sampler, a reference level, and a comparison circuit which compares the output level to the reference level. The comparison unit is often a differential amplifier. Its output controls a d-c amplifier circuit which drives the control, or pass transistors. The output of the control transistors is the power supply output.

The Model 1121 power supply has five individual circuits. There are two regulated high voltage supplies: -180 volts (floating) and +160 volts. There are three low voltage supply circuits, two of which are filament supplies (these are shown at the bottom of the power transformer). The third low voltage supply has two outputs regulated at +20 volts and -20 volts.

The -180 volt circuit uses two transformer secondary windings. These may be identified as the two windings at the top of the Power Supply Schematic drawing. The -180 volt supply is variable from approximately -40 volts to -180 volts, and is floating with respect to chassis ground. The power from this circuit drives the output of the Model 1121. Output power is supplied by the top winding, and is rectified by diodes CR1-CR4. Capacitor C101 is a filter. The output of this circuit is then regulated by the -180 volt regulator circuit.

The other secondary winding provides unregulated power for operating the -180 volt regulator, and is located immediately below the first secondary winding. The output of this winding is rectified by two full-wave rectifiers CR5-CR8. Filter capacitors C1 and C2 are located on the regulator circuit board. The output of this supply is referenced above and below the zero volt floating ground level.

In the regulator circuit, transistors Q101 and Q102 are the series control transistors. Q1 and Q4 are d-c amplifiers, and the emitter of Q4 drives Q101 and Q102. The comparison unit (Q2 and Q3) is an emitter-coupled differential amplifier. The base of Q2 is connected to the floating ground which is the reference level. The base of Q3 is not connected to an output sampling unit, but rather to the amplitude control circuit, Q5, 6, and 7.

The amplitude control circuit operates through the front-panel PROGRAM switch. In the MANUAL position, the collector of Q20 (terminal GG) is

connected directly to the base of Q6 (through terminal MM). Q20 is located in the lower right portion of the Power Supply Schematic near the title block. The amplitude control, R204, controls the base bias of Q20. The collector current of Q20 in turn, drives the base of Q6. Q6 drives Q5, and the collector current of Q5 is the input to the differential amplifier pair, Q2 and Q3. By varying the R204, the output current of Q5 controls the -180 volt regulator circuit within the range of approximately -40 volts to -180 volts. When the front-panel PROGRAM switch is in the REMOTE position, an E-H Model 930 Digital to Analog Converter circuit drives Q6.

Transistor Q7 provides an overload indication signal to the rear panel connector J102, for remote programming applications. As long as the +160 volt supply is on, the voltage at the junction of R18 and R19 is approximately 10 volts. If the overload circuit turns the +160 volt supply off, the voltage at the junction of R18 and R19 will drop towards zero. Similarly, if the input voltage at the base of Q6 should go positive far enough to forward bias CR4 (and the emitter base junction of Q7), Q7 will turn on and its collector voltage will drop towards zero. Either way, the signal level at the rear panel connector J102 will change.

Zener diode CR3 serves as a current limiter. Normally, the voltage across CR3 is somewhat less than its avalanche voltage, which is approximately 5 volts. The voltage at the base of Q4, therefore, cannot rise any more positive (with respect to the floating ground) than the avalanche voltage of CR3. This limits the positive voltage excursion at the bases of Q101 and Q102, and so limits the output current.

The +160 volt power supply is similar to the -180 volt supply. The power output from the third secondary winding is rectified by diodes CR9-CR12. C102 is a filter capacitor. This circuit is referred to chassis ground and the output is held at +160 volts with respect to ground. The fourth secondary winding provides unregulated power to operate the +160 volt regulator. Diodes CR13-CR16 are rectifiers, and C3 and C4 are filters. The center-tap is connected to the +160 volt bus.

The operation of the +160 volt regulator is similar to the operation of the -180 volt circuit, with two exceptions: this regulator is referred to chassis ground, and it has an overload protection circuit.

Q12 and Q13 form a differential amplifier, and is the comparison unit for this regulator. Zener diode CR9 is a voltage reference, and it is compared to the voltage at the center arm of trimming potentiometer R35. The differential amplifier drives the d-c amplifier, which is similar to the d-c amplifier circuit in the -180 volt regulator. CR8 is a current limiter, and it operates like CR3. Q103 and Q104 are the control transistors for this circuit.

The overload protection circuit is composed of transistors Q8 and Q9, which form a bistable multivibrator. Normally, Q8 is on and Q9 is biased off. If the emitter of Q11 goes sufficiently positive, current will flow through R31 and turn Q9 on. The voltage change at the collector of Q9 does two things; first, it turns off Q8, and second, it forward biases CR6, which drives the base of Q11 negative to turn off the power supply.

The overload circuit operates in conjunction with the combination overload indicator lamp and reset switch. Ordinarily, the voltage across the neon lamp is not high enough to fire it. When Q103 and Q104 are turned off, the +160 volt bus drops toward ground, and the neon lamp fires. The overload reset switch, when closed, provides a positive pulse which turns Q8 off, and resets the overload multivibrator.

The third circuit is the low voltage ±20 volt power supply. The output of the fifth power supply secondary winding is rectified by diodes CR17-CR20. C103 and C104 are filter capacitors.

In the +20 volt regulator, CR12 is the reference element. The voltage at the base of Q16 is compared to the voltage at the center arm of trimming potentiometer R53. R53 adjusts the regulator output. Q16 and Q17 are the comparison circuit. Q14 is the d-c amplifier, and its emitter current drives the base of control transistor Q105.

The -20 volt regulator is different from the +20 volt circuit. Q18 is the comparison unit. The +20 volt bus is the reference level. The output sample is the voltage of the junction of R57 and R58. That voltage determines the emitter voltage of Q18, which drives the base of Q15. Q15 is the d-c amplifier and it controls the pass transistor Q106. Zener diode CR10 is connected between the -20 volt bus and resistors R42 and R47. It holds the voltage at that junction 5 volts negative with respect to the -20 volt bus, to help eliminate ripple at the base of Q106.

There are two additional circuits shown on the lower right corner of the schematic. These are Q19, Q20 and their associated components. The collector current from Q19 drives the baseline offset circuit when the PROGRAM switch is in the MANUAL position. R206 is the front-panel OFFSET control. It controls the base current of Q19, which controls the collector current available to drive the offset circuit. Similarly, the collector current from Q20 drives the amplitude control circuit at the base of Q6. R204 is the front panel AMPLITUDE control; its function and operation is similar to that of the OFFSET control. For remote programming, the functions of Q19 and Q20 are replaced by two E-H Model 930 Digital to Analog Converter circuits.

SECTION 5

MODEL 1421/1121
CALIBRATION PROCEDURES

5-1 MANUAL CALIBRATION

Since the Model 1121 contributes some delay and width, the Model 1421 is calibrated to the Model 1121 output. For accurate time measurement and pulse waveform observation, use a dual trace (dual input) oscilloscope with calibrated sweep and vertical amplifier circuits. The sampling scope--such as the Tektronix type 661 with type 4S1 and type 5T1A plug-in units is ideal. The effective risetime of this Tektronix sampling oscilloscope is approximately 350 picoseconds. Connect the Model 1421 trigger pulse to channel A and the Model 1121 output pulse to channel B. Use the Model 1121 internal attenuator (at X10) to avoid damaging any low wattage 1-watt T-pads. Trigger the scope internally on channel A.

a. DELAY TIME CALIBRATION - Model 1421

1) Set R211 (manual DELAY) control to 10 turns.

2) Observe the time difference between the Model 1421 trigger pulse leading edge 50% point and the Model 1121 output pulse leading edge 50% point.

3) Adjust R103 for 1000 nanoseconds ± 5% delay.

4) Adjust R211 to 0.1 turns.

5) Adjust R104 for 10 nanoseconds ± 3 nanoseconds.

6) There may be interaction between R103 and R104; repeat adjustment as necessary. Check intermediate points in the delay range to assure accuracy of ± 3 nanoseconds, ± 5% of reading over complete range.

b. WIDTH CALIBRATION - Model 1421

Output pulse width calibration is similar to delay time calibration.

1) Set R209 (manual WIDTH control) to 10 turns.

2) Adjust R105 for 1000 nanoseconds ±5% pulse width.

3) Adjust R209 to 0.1 turns.

4) Adjust R106 for 10 nanoseconds ± 3 nanoseconds pulse width as measured at 50% amplitude.

5) There may be interaction between R105 and R106. Repeat necessary adjustments. Check intermediate points in the width range to assure accuracy of ± 3 nanoseconds, ± 5% of reading over complete range.

Typical readings are:

R209	0.1 turns	0.2 turns	0.5 turns	1 turn	5 turns	10 turns
Width	12 ns	19 ns	52 ns	100 ns	500 ns	1000 ns

5-2 REMOTE CALIBRATION Model 1421

a. DELAY, WIDTH

1) Turn program control switch to the remote position.

2) Set the delay Digital to Analog Converter input count to 1000.

3) Adjust the delay Digital to Analog "scale factor" adjust potentiometer for 1000 nanoseconds delay.

4) Set the delay Digital to Analog Converter input count to 10.

5) Check delay time to be 10 nanoseconds ± 3 nanoseconds. If out of specification, adjust the Digital to Analog "Zero" adjust potentiometer.

6) The same procedure is used to calibrate the width Digital to Analog Converter.

5-3 MANUAL CALIBRATION Model 1121

a. AMPLITUDE CALIBRATION

1) Set R204 (manual amplitude) control to 10 turns.

2) Adjust R15 (shown on Drawing D-11804) for 50 volts ± 5% output pulse amplitude. only when -20 is -15

b. BASELINE OFFSET CALIBRATION

1) Set R206 (manual offset) control to 10 turns. Set offset polarity to (-). Note all adjustments are located on the offset driver printed circuit board.

2) Adjust R4 for -5 volts ± 5% baseline offset.

3) Turn front panel control to (+) offset.

4) Adjust R5 for +5 volts ± 5% baseline offset.

5) Set R206 (manual offset) control to "Zero" turns.

6) Adjust R1 for 0V ± 100 mv baseline offset.

7) Recheck the 5 volt offset settings as well as intermediate points on the range and readjust R1, R4, R5 if necessary to assure ± 5% ± 100 mv accuracy over complete range.

5-4 REMOTE CALIBRATION Model 1121

a. AMPLITUDE

1) Turn program switch to remote position.

2) Set amplitude Digital to Analog Converter input count to 500.

3) Adjust the amplitude Digital to Analog "scale factor" potentiometer for 50 volts ± 5% output pulse amplitude.

b. BASELINE OFFSET

1) Set offset Digital to Analog Converter input count to 500.

2) Adjust offset Digital to Analog Converter "scale factor" adjust potentiometer for 5 volts ± 5% baseline offset.

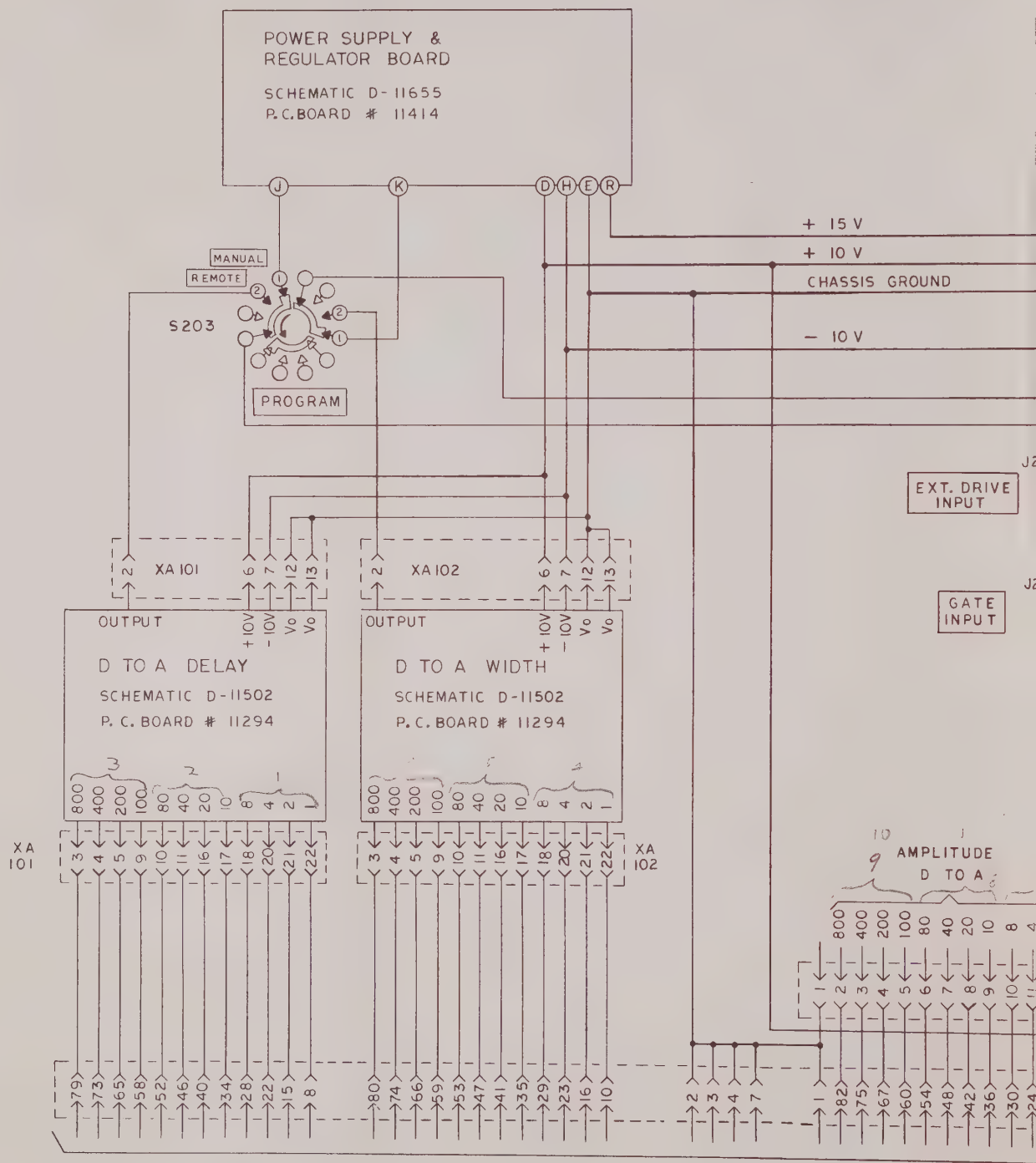
3) Set Digital to Analog Converter input count to "Zero".

4) Adjust Digital to Analog Converter "Zero" adjust potentiometer for 0V ± 100 mv baseline offset.

SECTION 6

DRAWING INDEX AND DRAWINGS

TITLE	DRAWING
1) MODEL 1421 - MASTER SCHEMATIC	D-11657
2) MODEL 1421 - TIMING CIRCUIT SCHEMATIC	D-11656
3) MODEL 1421 - POWER SUPPLY & REGULATOR BOARD . .	D-11655
4) MODEL 1121 - MASTER SCHEMATIC	D-11806
5) MODEL 1121 - OUTPUT CIRCUIT RELAY & OFFSET DRIVER	D-11805
6) MODEL 1121 - ATTENUATOR SCHEMATIC.	D-11853
7) MODEL 1121 - POWER SUPPLY RECTIFIER & REGULATOR BOARD SCHEMATIC	D-11804
8) MODEL 930 - DIGITAL TO ANALOG CONVERTER, + DC. .	D-11502


POWER SUPPLY &
REGULATOR BOARD
SCHEMATIC D-11655
P.C.BOARD # 11414
J
K
D
H
E
R
+ 15 V
+ 10 V
CHASSIS GROUND
- 10 V
MANUAL
REMOTE
S203
PROGRAM
EXT. DRIVE INPUT
GATE INPUT
XA 101
XA 102
OUTPUT
+10V
-10V
Vo
Vo
D TO A DELAY
SCHEMATIC D-11502
P. C. BOARD # 11294
D TO A WIDTH
SCHEMATIC D-11502
P. C. BOARD # 11294
800
400
200
100
80
40
20
10
8
4
2
1
AMPLITUDE
D TO A

D-11657 B

REVISIONS						
ISSUE	REVISION	DATE	DRAWN	CHK'D	APPV'D	E.O.
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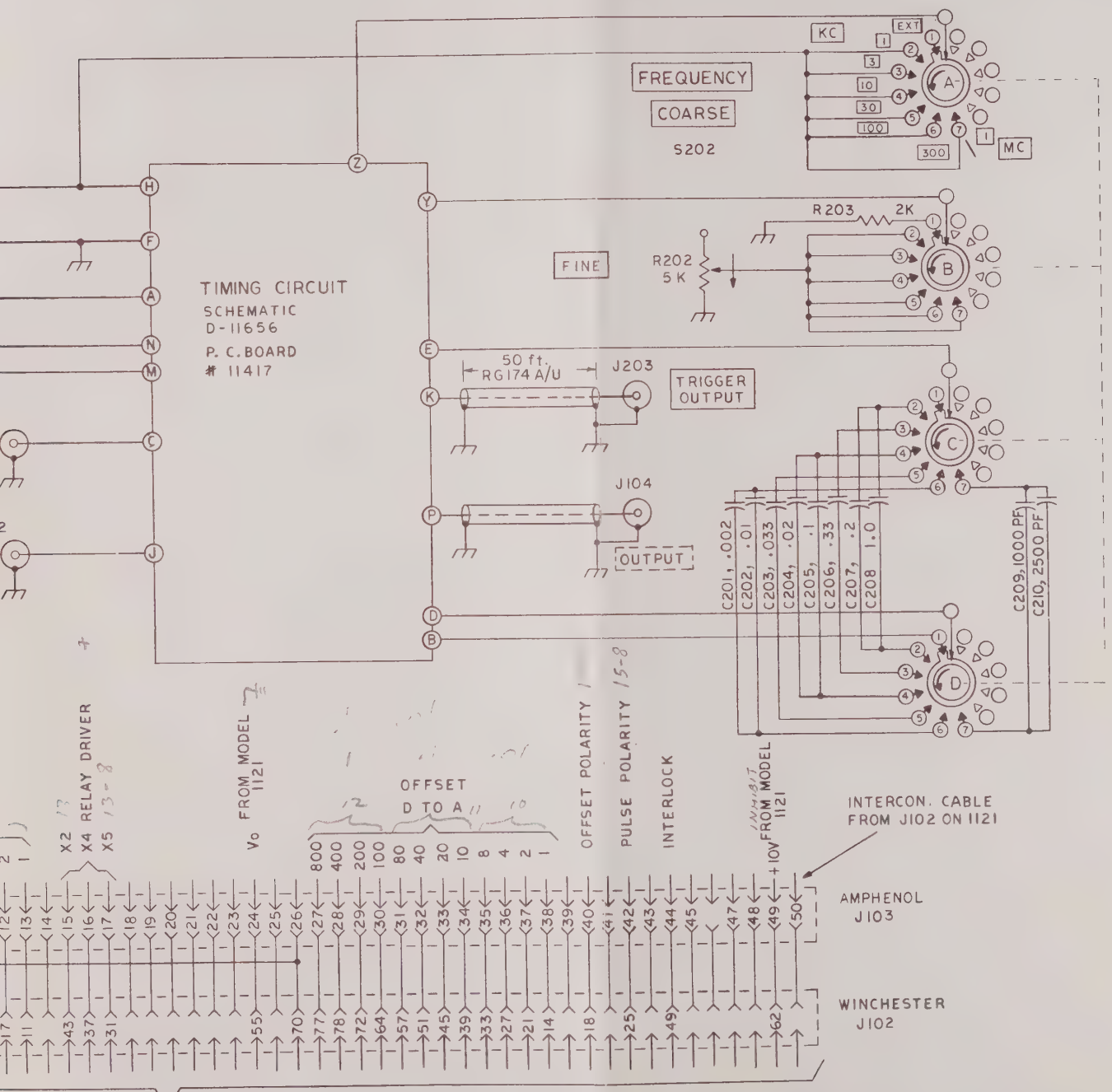
B	PILOT RUN EVALUATION	11-1-65				



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ITEM NO	PART NO.	DESCRIPTION	QTY

MATERIAL LIST

UNLESS OTHERWISE SPECIFIED
SCALE
DIMENSIONS ARE IN INCHES
DECIMALS ± XX = ± XXX =
ANGLES ±
MACHINED SURFACES
DO NOT SCALE DRAWING
FINISH

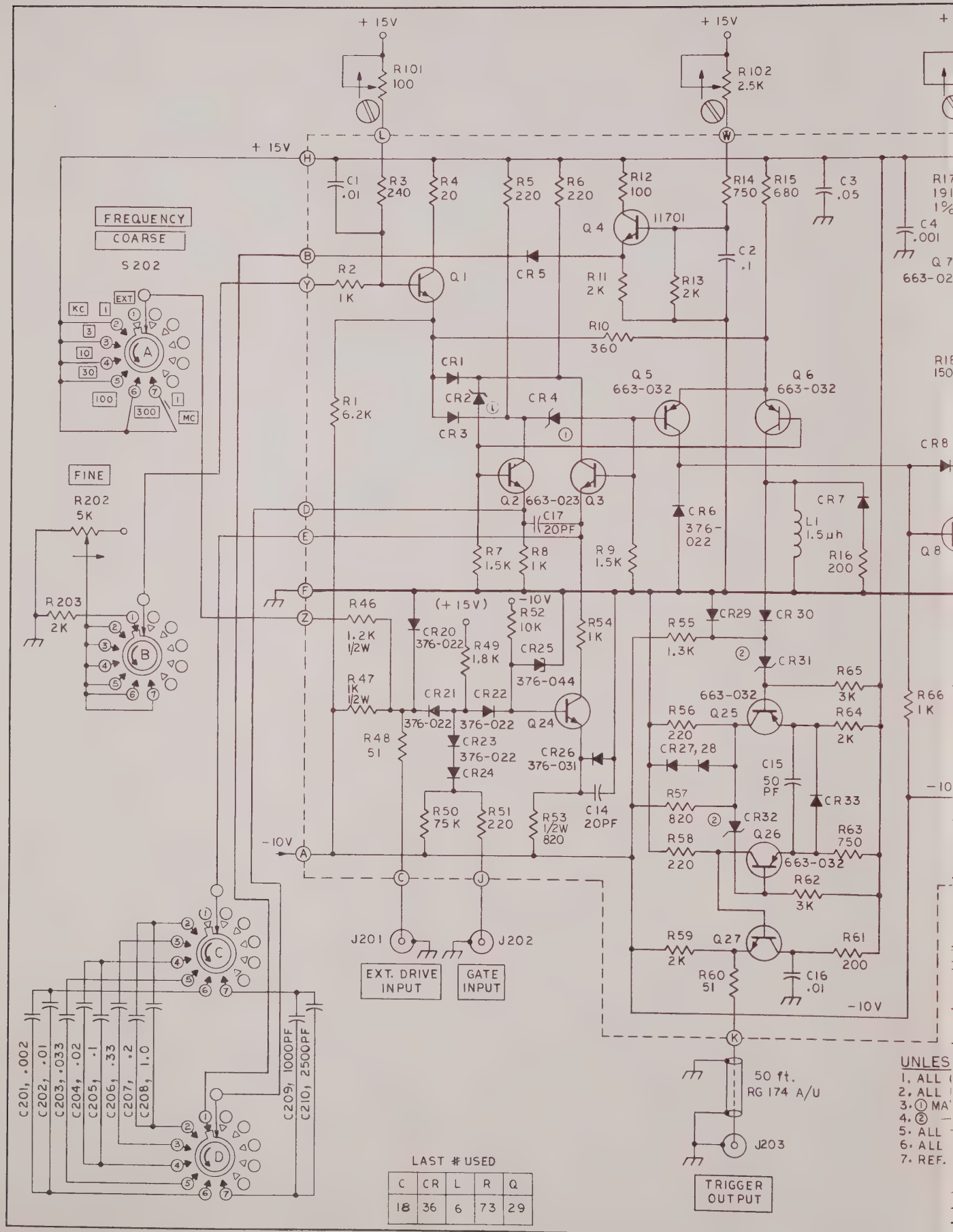
NEXT ASS'Y 1421 | REQ'D 1 | USED ON

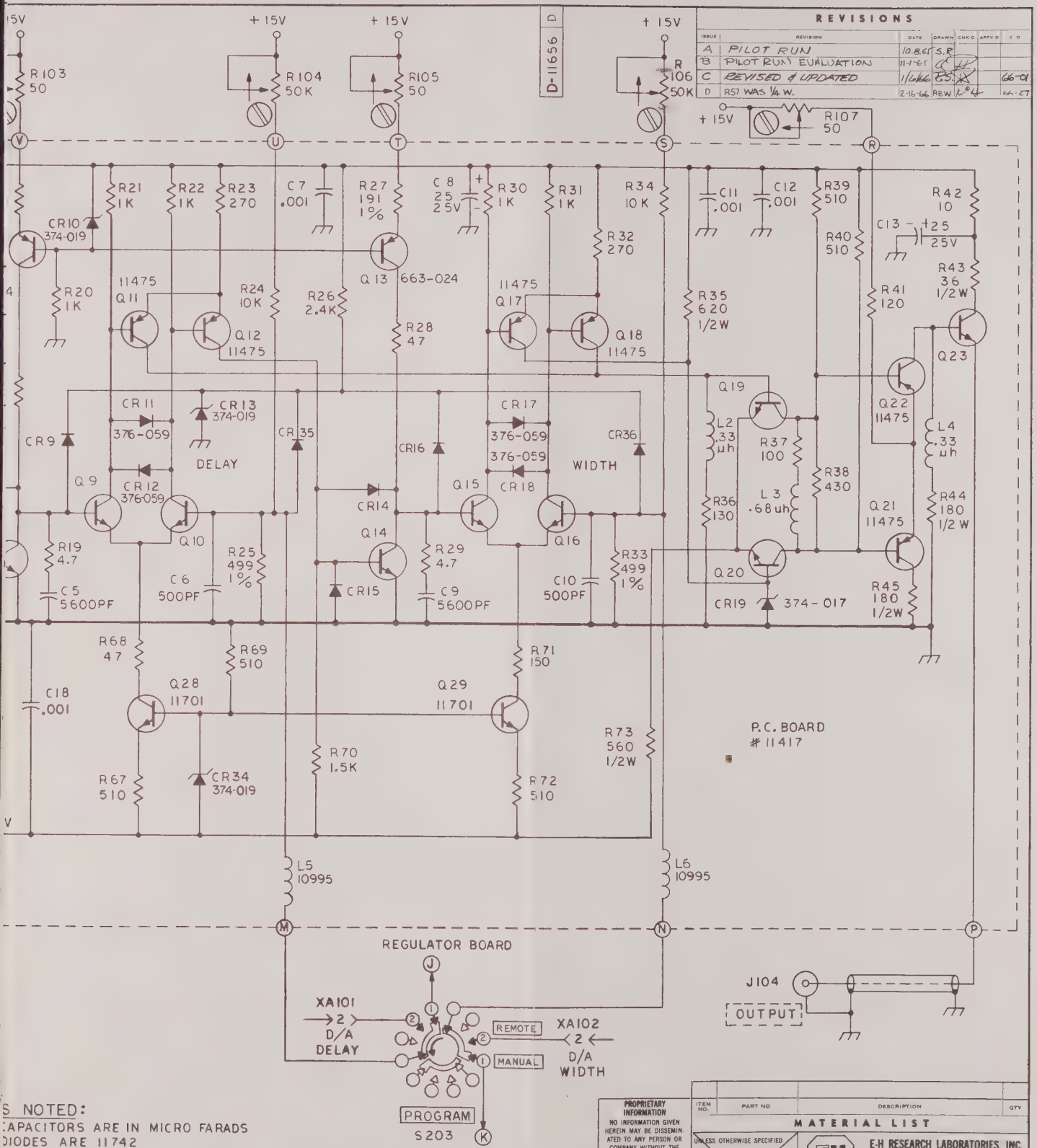
E-H RESEARCH LABORATORIES, INC.
OAKLAND, CALIFORNIA

TITLE
MASTER SCHEMATIC

MODEL 1421

	INITIALS	DATE	
DRAWN	STEVAN	10.18.65	D-11657
CHK'D	[illegible]	11/2/65	ISSUE B
APP'D	REB	11-16-65	SHEET NO. 1 OF 1 SHEETS


+ 15V
R101 100
R102 2.5K
FREQUENCY
COARSE
S202
FINE
R202 5K
R203 2K
R1 6.2K
R2 1K
C1 .01
R3 240
R4 20
R5 220
R6 220
R12 100
R14 750
R15 680
C3 .05
C4 .001
Q4 11701
C2 .1
R11 2K
R13 2K
R10 360
Q1
CR5
CR1
CR2
CR3
CR4
Q5 663-032
Q6 663-032
Q2 663-023
Q3
C17 20PF
CR6 376-022
CR7
L1 1.5µh
R16 200
R7 1.5K
R8 1K
R9 1.5K
R46 1.2K 1/2W
(+15V)
-10V
R52 10K
R54 1K
CR20 376-022
R49 1.8K
CR25 376-044
R47 1K 1/2W
CR21
CR22
Q24
R48 51
CR23 376-022
CR24
CR26 376-031
C14 20PF
R50 75K
R51 220
R53 1/2W 820
CR29
CR30
R55 1.3K
CR31
R65 3K
663-032
Q25
R56 220
R64 2K
CR27, 28
C15 50 PF
CR33
R57 820
CR32
Q26
R58 220
R63 750
663-032
R62 3K
R59 2K
Q27
R61 200
R60 51
C16 .01
-10V
J201
J202
EXT. DRIVE INPUT
GATE INPUT
C201, .002
C202, .01
C203, .033
C204, .02
C205, .1
C206, .33
C207, .2
C208, 1.0
C209, 1000PF
C210, 2500PF
50 ft. RG 174 A/U
J203
TRIGGER OUTPUT
LAST # USED
C 18
CR 36
L 6
R 73
Q 29
UNLES
1. ALL
2. ALL
3. ① MA
4. ②
5. ALL
6. ALL
7. REF.



S NOTED:
CAPACITORS ARE IN MICRO FARADS
DIODES ARE 11742
TCHED PAIRS DIODES ARE 11731
" " 11730
RESISTORS ARE IN OHMS, 1/4W, 5%
TRANSISTORS ARE 663-009
DWG., MASTER SCHEMATIC D-11657

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ITEM NO. | PART NO | DESCRIPTION | QTY

MATERIAL LIST

UNLESS OTHERWISE SPECIFIED
SCALE
DIMENSIONS ARE IN INCHES
DECIMALS ± .XX ± .XXX
ANGLES ±
MACHINED SURFACES √
DO NOT SCALE DRAWING
FINISH

E-H RESEARCH LABORATORIES, INC.
OAKLAND, CALIFORNIA

TITLE: TIMING CIRCUIT SCHEMATIC

MODEL 1421

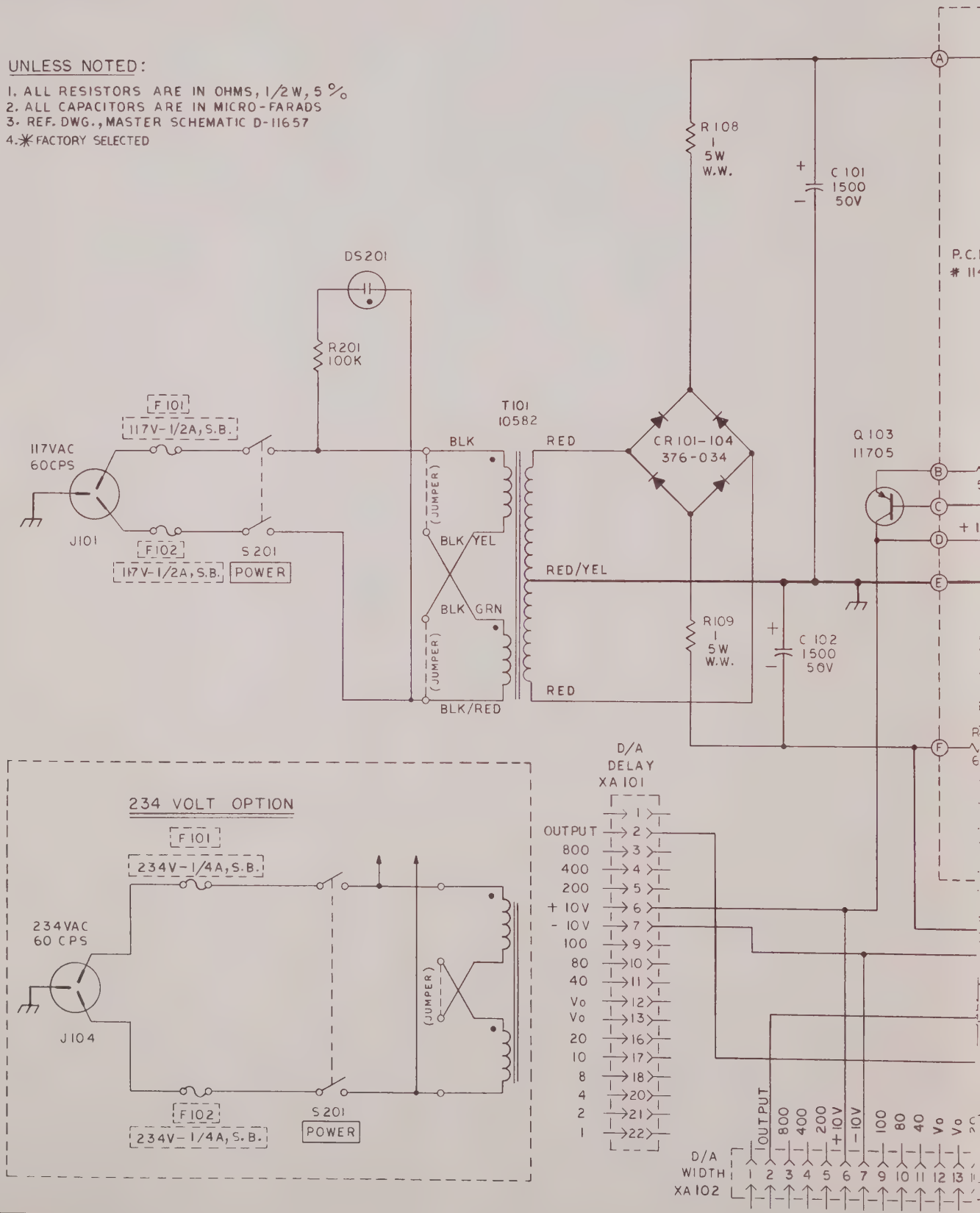
	INITIALS	DATE		ISSUE
DRAWN	STEVAN	10.8.65	D-11656	D
CHK'D		11-2-65		
APP'D	REB	11-10-65	SHEET NO 1 OF 1 SHEETS	

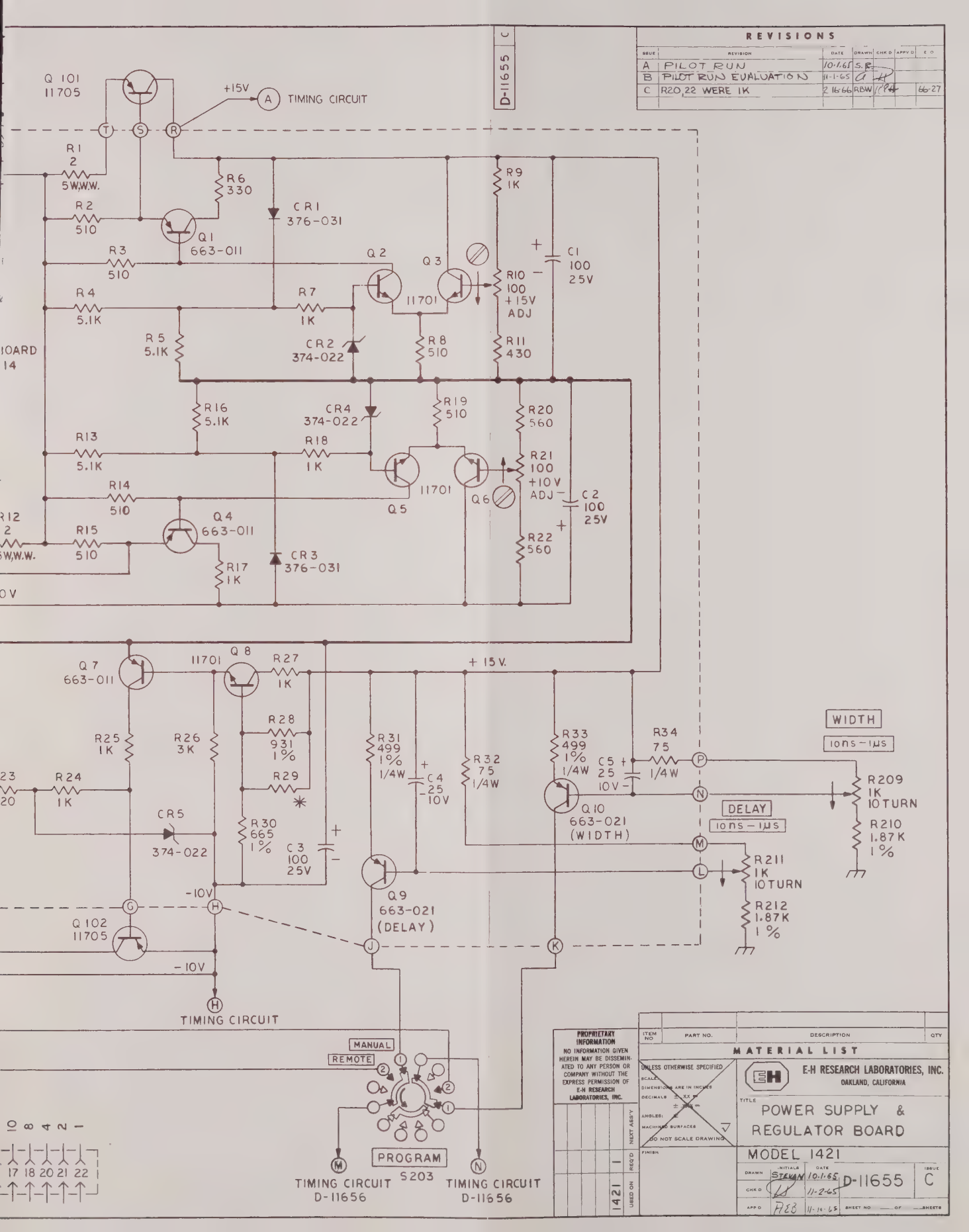
NEXT ASS'Y
REQ'D 1
USED ON 1421

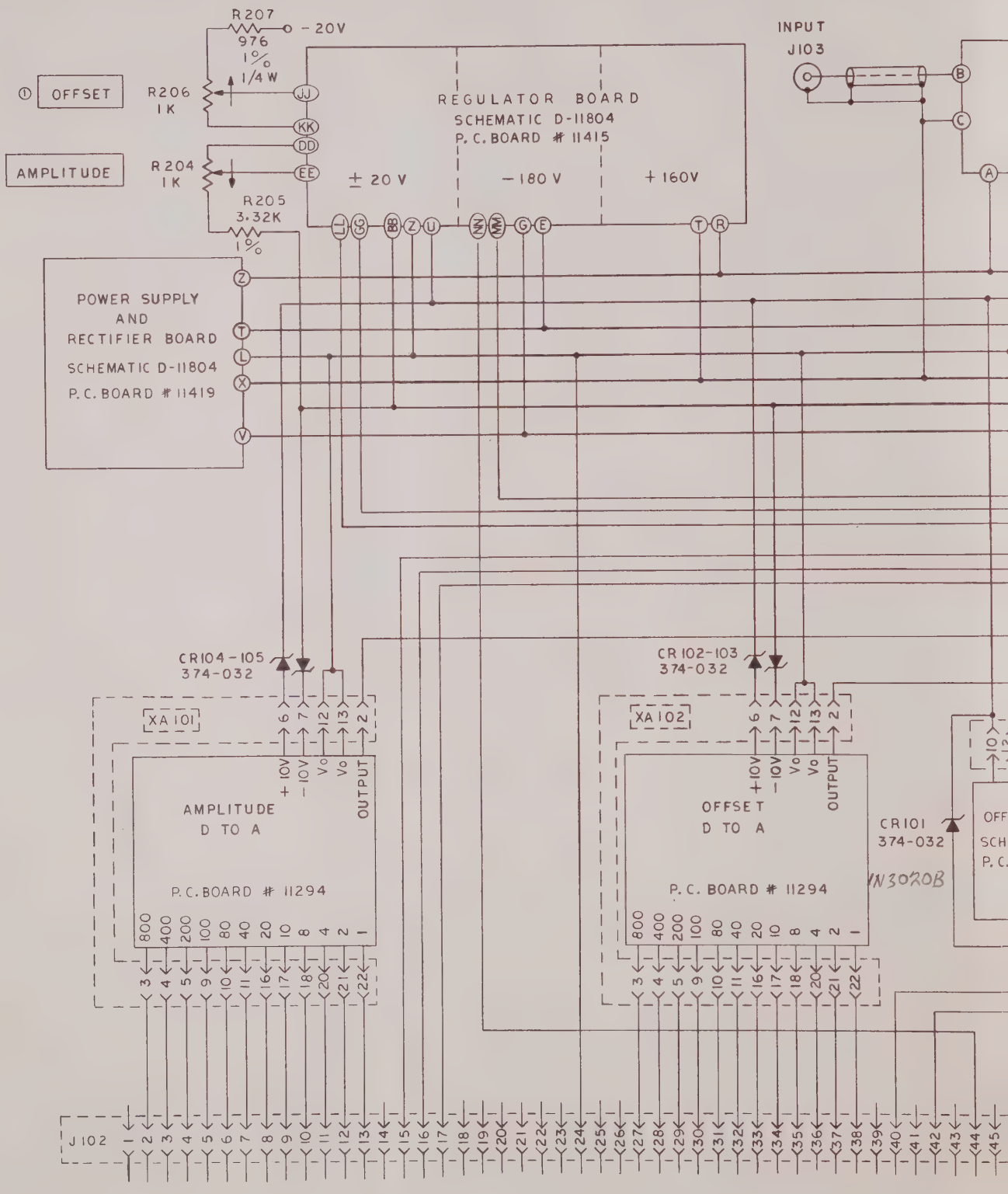
LAST # USED				
	C	CR	R	Q
BOARD	5	5	34	10

UNLESS NOTED:

1. ALL RESISTORS ARE IN OHMS, 1/2W, 5 %
2. ALL CAPACITORS ARE IN MICRO-FARADS
3. REF. DWG., MASTER SCHEMATIC D-11657
4. ✳ FACTORY SELECTED

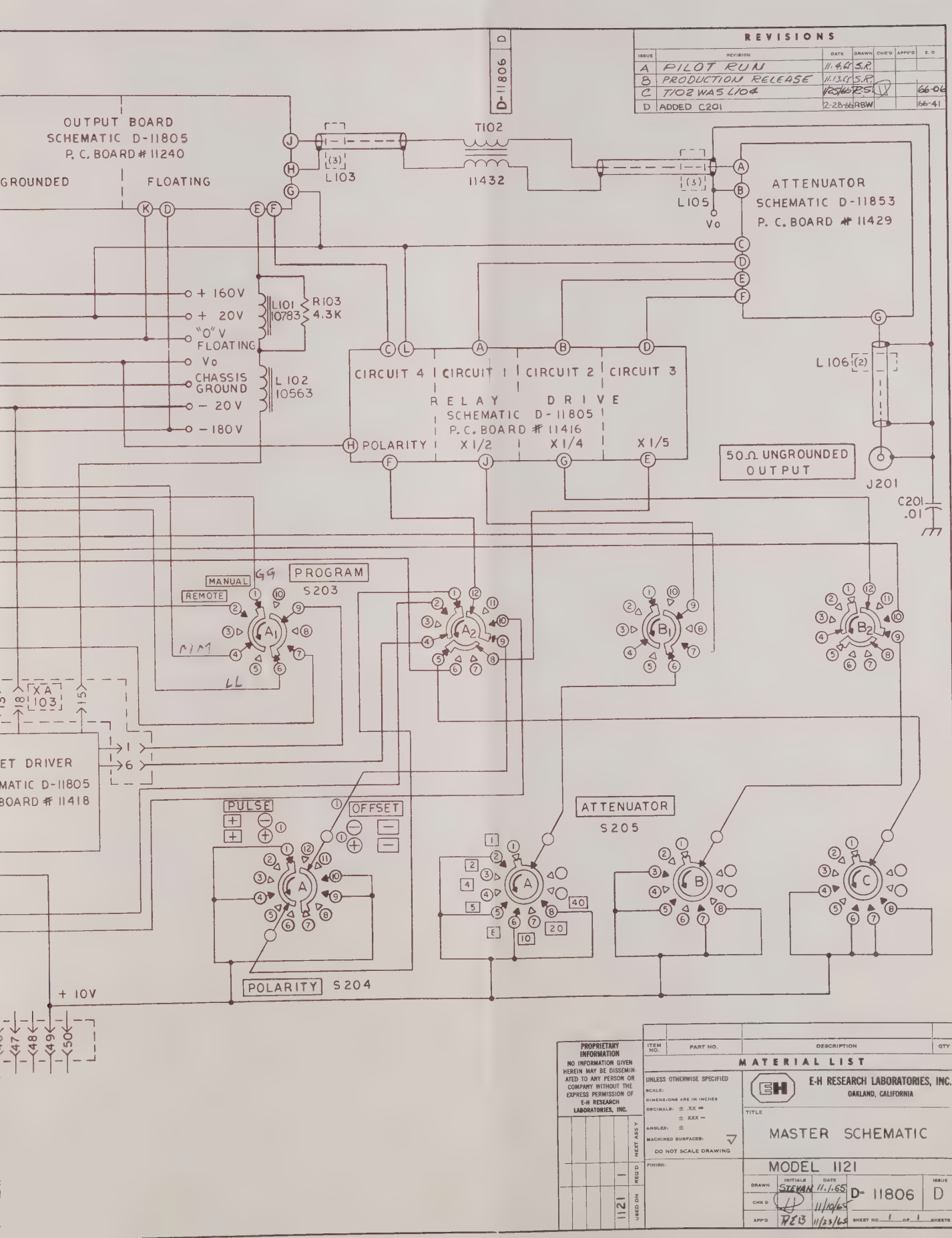


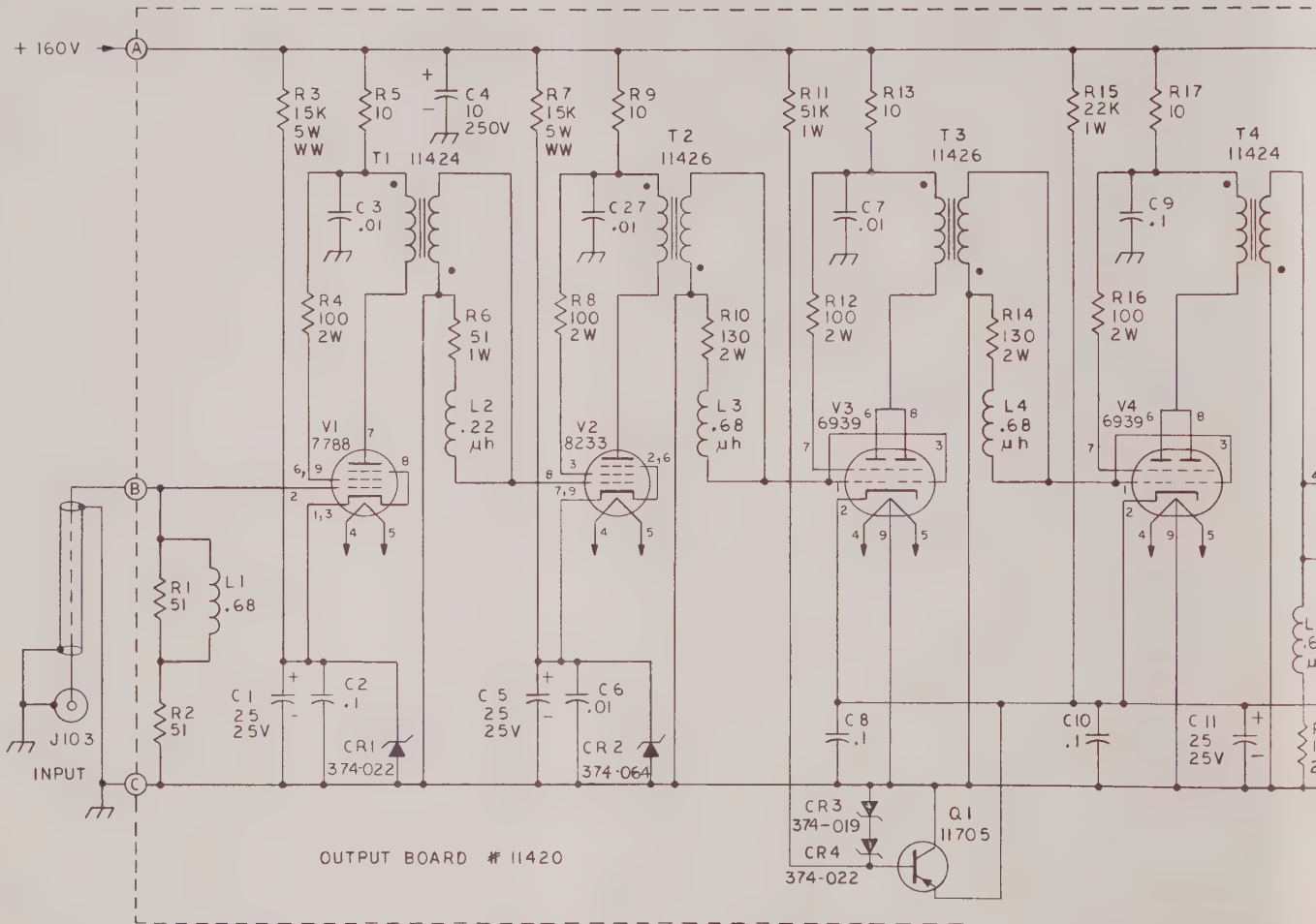

D-11655 C
REVISIONS
ISSUE | REVISION | DATE | DRAWN | CHK'D | APPV'D | E.O.
A | PILOT RUN | 10-1-65 | S.B.
B | PILOT RUN EVALUATION | 11-1-65 | G.H.
C | R20,22 WERE 1K | 2-16-66 | RBW | 66-27
Q 101 11705
+15V
A TIMING CIRCUIT
R1 2 5W,W.W.
R2 510
R3 510
R4 5.1K
R5 5.1K
R6 330
R7 1K
R8 510
R9 1K
R10 100 +15V ADJ
R11 430
C1 100 25V
CR1 376-031
CR2 374-022
Q1 663-011
Q2
Q3
11701
R16 5.1K
R18 1K
R19 510
R20 560
R21 100 +10V ADJ
R22 560
C2 100 25V
CR4 374-022
Q5
Q6
R13 5.1K
R14 510
R15 510
R17 1K
Q4 663-011
CR3 376-031
Q 7 663-011
Q 8 11701
R27 1K
+15 V.
R25 1K
R26 3K
R28 931 1%
R29
R30 665 1%
R23 20
R24 1K
CR5 374-022
C3 100 25V
R31 499 1% 1/4W
C4 25 10V
R32 75 1/4W
R33 499 1% 1/4W
C5 25 10V
R34 75 1/4W
Q10 663-021 (WIDTH)
Q9 663-021 (DELAY)
Q 102 11705
-10V
-10V
TIMING CIRCUIT
WIDTH
10ns – 1μs
DELAY
10ns – 1μs
R209 1K 10 TURN
R210 1.87K 1%
R211 1K 10 TURN
R212 1.87K 1%
MANUAL
REMOTE
PROGRAM
S203
TIMING CIRCUIT D-11656
TIMING CIRCUIT D-11656
PROPRIETARY INFORMATION
NO INFORMATION GIVEN HEREIN MAY BE DISSEMINATED TO ANY PERSON OR COMPANY WITHOUT THE EXPRESS PERMISSION OF E-H RESEARCH LABORATORIES, INC.
ITEM NO | PART NO. | DESCRIPTION | QTY
MATERIAL LIST
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
DECIMALS .XX ±
ANGLES ±
MACHINED SURFACES
DO NOT SCALE DRAWING
FINISH
E-H RESEARCH LABORATORIES, INC.
OAKLAND, CALIFORNIA
TITLE
POWER SUPPLY & REGULATOR BOARD
MODEL 1421
DRAWN STEVAN 10-1-65
CHK'D 11-2-65
APP'D AEB 11-14-65
D-11655
ISSUE C
SHEET NO — OF — SHEETS
NEXT ASSY
REQ'D 1
USED ON 1421

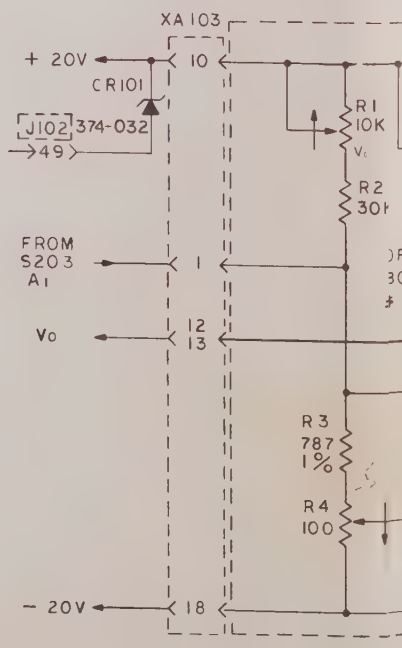


UNLESS NOTED:

1. ① INDICATES NOMENCLATURE PRINTED RED ON FRONT PANEL.


D-11806 D
REVISIONS
ISSUE | REVISION | DATE | DRAWN | CHK'D | APPV'D | E.O
A | PILOT RUN | 11.4.64 | S.R.
B | PRODUCTION RELEASE | 11.13.64 | S.R.
C | T102 WAS L104 | 12-5-66 | RBS | 66-06
D | ADDED C201 | 2-28-66 | RBW | 66-41
OUTPUT BOARD
SCHEMATIC D-11805
P. C. BOARD # 11240
GROUNDED
FLOATING
T102
11432
L103
(3)
L105
(3)
Vo
ATTENUATOR
SCHEMATIC D-11853
P. C. BOARD # 11429
+ 160V
+ 20V
"0" V FLOATING
Vo
CHASSIS GROUND
- 20V
- 180V
L101
10783
R103
4.3K
L102
10563
CIRCUIT 4
CIRCUIT 1
CIRCUIT 2
CIRCUIT 3
RELAY DRIVE
SCHEMATIC D-11805
P. C. BOARD # 11416
POLARITY
X1/2
X1/4
X1/5
L106
(2)
50Ω UNGROUNDED OUTPUT
J201
C201
.01
MANUAL
REMOTE
PROGRAM
S203
A1
A2
B1
B2
XA 103
ET DRIVER
MATIC D-11805
BOARD # 11418
PULSE
OFFSET
POLARITY S204
ATTENUATOR
S205
+ 10V
PROPRIETARY INFORMATION
NO INFORMATION GIVEN HEREIN MAY BE DISSEMINATED TO ANY PERSON OR COMPANY WITHOUT THE EXPRESS PERMISSION OF E-H RESEARCH LABORATORIES, INC.
ITEM NO. | PART NO. | DESCRIPTION | QTY
MATERIAL LIST
UNLESS OTHERWISE SPECIFIED
SCALE:
DIMENSIONS ARE IN INCHES
DECIMALS: ± .XX
± .XXX
ANGLES: ±
MACHINED SURFACES:
DO NOT SCALE DRAWING
FINISH:
E-H RESEARCH LABORATORIES, INC.
OAKLAND, CALIFORNIA
TITLE
MASTER SCHEMATIC
MODEL 1121
DRAWN | INITIALS | DATE
STEVAN | 11.1.65
CHK'D | 11/10/65
APP'D | RBS | 11/23/65
D-11806
ISSUE D
SHEET NO 1 OF 1 SHEETS
NEXT ASS'Y
REQ'D 1
USED ON 1121



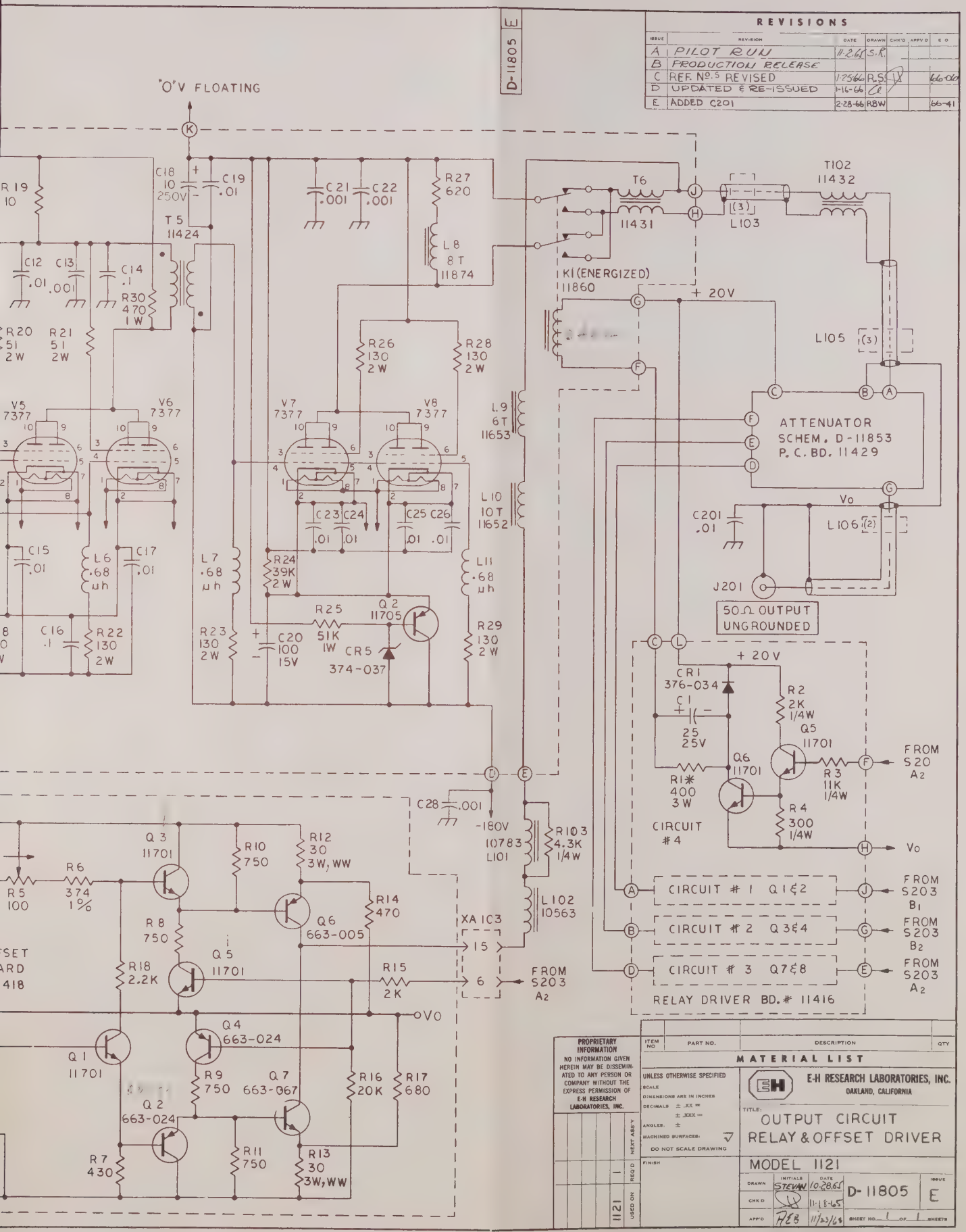


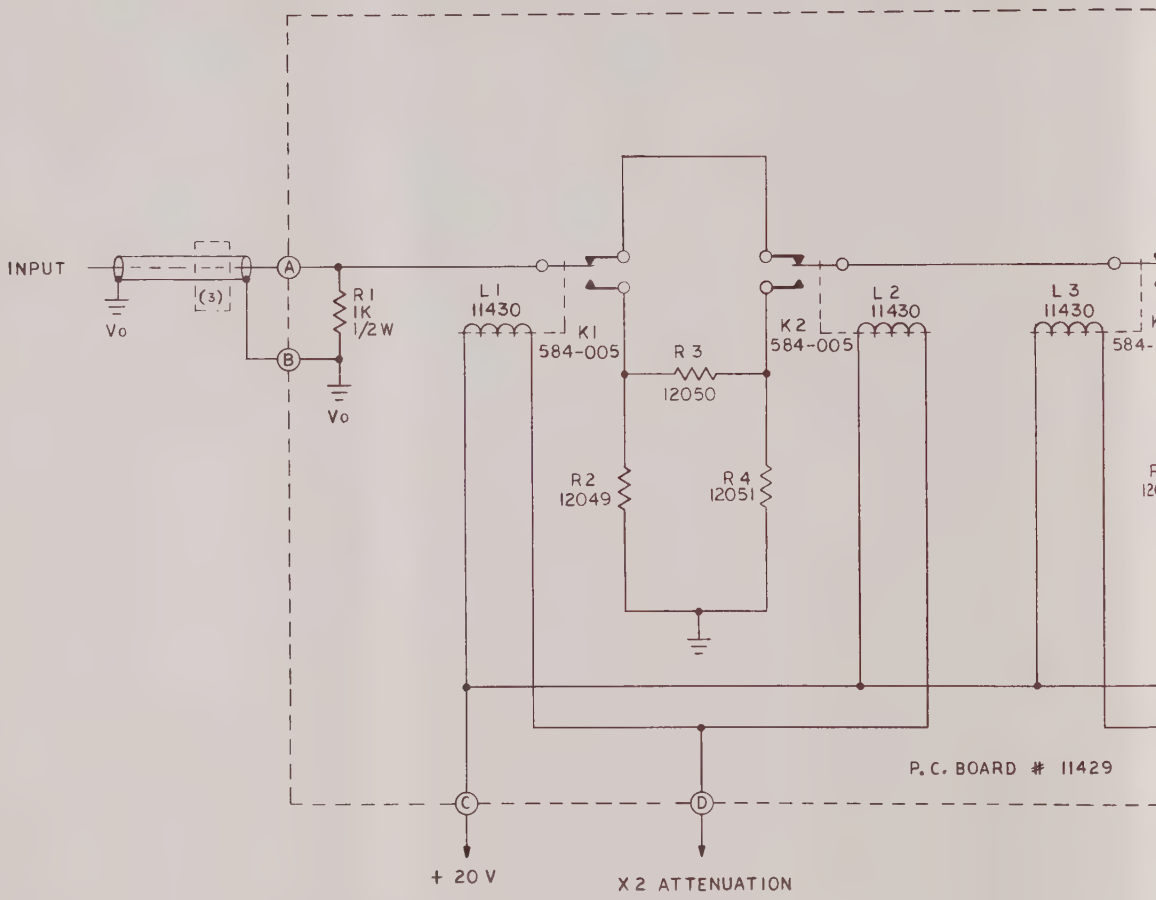
UNLESS NOTED:

1. ALL RESISTORS ARE IN OHMS, 1/2W, 5%
2. ALL CAPACITORS ARE IN MICRO-FARADS
3. R1 * IN CIRCUIT # 1, 2 & 3 IS 200Ω, 5W.
4. REF. DWG., MASTER SCHEMATIC D-11806
5. FILLAMENT HOOK UP SHOWN ON DWG D-11804

LAST # USED

	C	CR	R	Q	L	T	V	K
OUTPUT CIRCUIT	28	5	30	2	11	6	8	1
RELAY DRIVER	—	—	17	7	—	—	—	—
OFFSET DRIVER	1	1	4	2	—	—	—	—


D-11805 E
REVISIONS
ISSUE | REVISION | DATE | DRAWN | CHK'D | APP'V'D | E.O.
A | PILOT RUN | 11-2-65 | S.R.
B | PRODUCTION RELEASE
C | REF. No.5 REVISED | 1-25-66 | R.S. | | 66-00
D | UPDATED & RE-ISSUED | 1-16-66 | CL
E | ADDED C201 | 2-28-66 | RBW | | 66-41
"O"V FLOATING
K
C18 10 250V
C19 .01
T5 11424
C21 .001
C22 .001
R27 620
L8 8T 11874
T6 11431
T102 11432
L103 (3)
K1 (ENERGIZED) 11860
+ 20V
L105 (3)
R19 10
C12 .01
C13 .001
C14 .1
R30 470 1W
R20 51 2W
R21 51 2W
R26 130 2W
R28 130 2W
V5 7377
V6 7377
V7 7377
V8 7377
L9 6T 11653
L10 10T 11652
ATTENUATOR SCHEM. D-11853 P.C. BD. 11429
C23 .01
C24 .01
C25 .01
C26 .01
Vo
C201 .01
L106 (2)
J201
50Ω OUTPUT UNGROUNDED
C15 .01
L6 .68 μh
C17 .01
L7 .68 μh
L11 .68 μh
R24 39K 2W
R25 51K 1W
Q2 11705
CR5 374-037
C20 100 15V
R22 130 2W
C16 .1
R23 130 2W
R29 130 2W
+ 20V
CR1 376-034
C1 25 25V
R2 2K 1/4W
Q5 11701
Q6 11701
R1* 400 3W
R3 11K 1/4W
R4 300 1/4W
CIRCUIT #4
FROM S20 A2
Vo
C28 .001
-180V
10783 L101
R103 4.3K 1/4W
L102 10563
XA1C3
15
6
FROM S203 A2
CIRCUIT # 1 Q1&2
CIRCUIT # 2 Q3&4
CIRCUIT # 3 Q7&8
FROM S203 B1
FROM S203 B2
FROM S203 A2
RELAY DRIVER BD. # 11416
Q3 11701
R10 750
R12 30 3W, WW
R6 374 1%
R5 100
R14 470
Q6 663-005
R8 750
Q5 11701
R18 2.2K
R15 2K
Vo
Q4 663-024
Q1 11701
R9 750
Q7 663-067
R16 20K
R17 680
Q2 663-024
R7 430
R11 750
R13 30 3W, WW
PROPRIETARY INFORMATION
NO INFORMATION GIVEN HEREIN MAY BE DISSEMINATED TO ANY PERSON OR COMPANY WITHOUT THE EXPRESS PERMISSION OF E-H RESEARCH LABORATORIES, INC.
ITEM NO | PART NO. | DESCRIPTION | QTY
MATERIAL LIST
UNLESS OTHERWISE SPECIFIED
SCALE
DIMENSIONS ARE IN INCHES
DECIMALS ± .XX = ± .XXX =
ANGLES: ±
MACHINED SURFACES:
DO NOT SCALE DRAWING
FINISH
E-H RESEARCH LABORATORIES, INC. OAKLAND, CALIFORNIA
TITLE: OUTPUT CIRCUIT RELAY & OFFSET DRIVER
MODEL 1121
DRAWN STEVAN 10-28-65
CHK'D 11-18-65
APP'D HEB 11/23/65
D-11805 ISSUE E
SHEET NO. 1 OF 1 SHEETS
NEXT ASS'Y
REQ'D 1
USED ON 1121

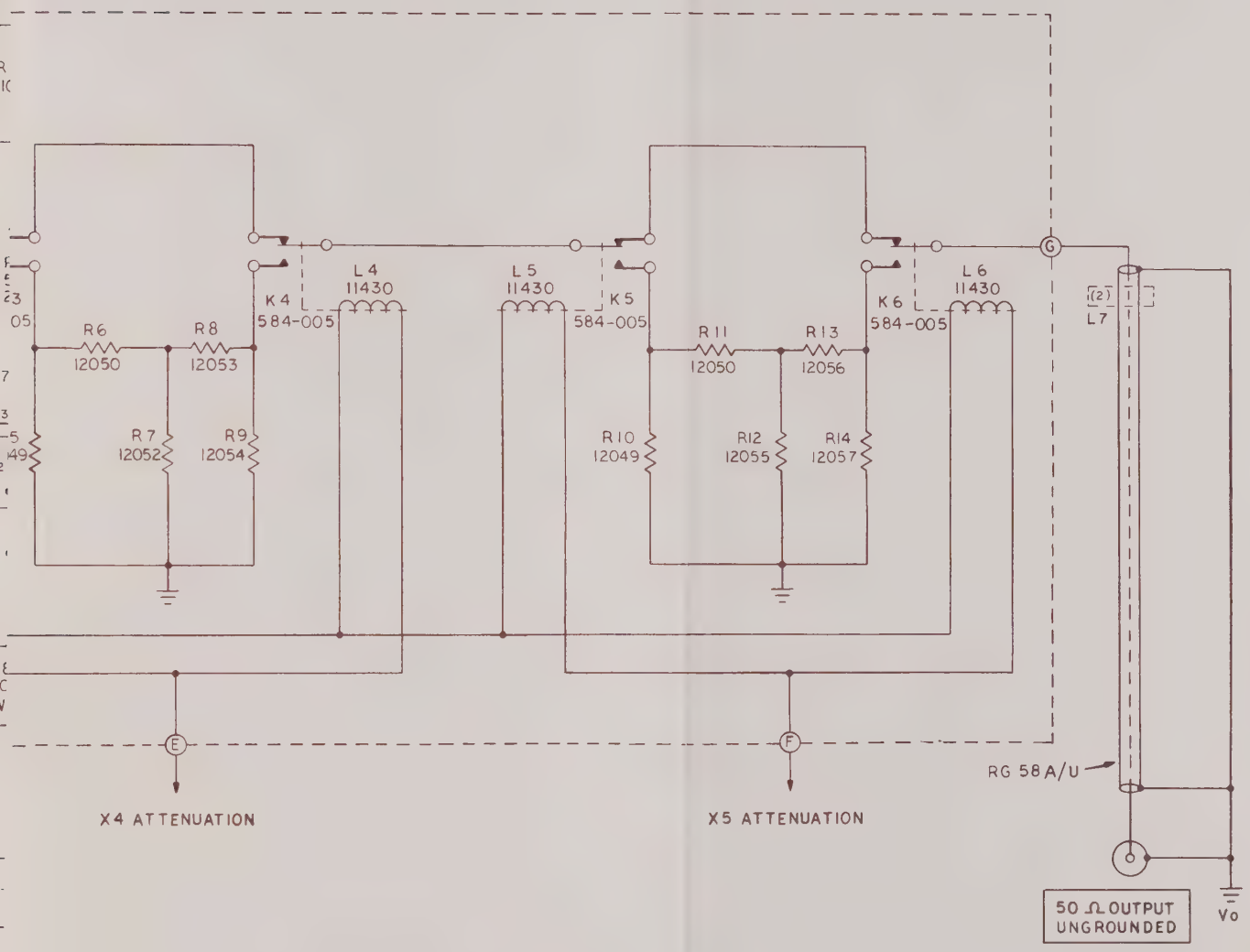


UNLESS NOTED:

1. ALL RESISTORS ARE IN OHMS, 5%
2. REF. DWG., C-11363 ASSEMBLY

D-11853B

REVISIONS						
ISSUE	REVISION	DATE	DRAWN	CHK'D	APPV'D	E O
A	INITIAL RELEASE	11-9-65	S.P.			
B	REVISED RESISTORS	2-11-66	RBW	LCH		66-29



PROPRIETARY INFORMATION
NO INFORMATION GIVEN HEREIN MAY BE DISSEMINATED TO ANY PERSON OR COMPANY WITHOUT THE EXPRESS PERMISSION OF E-H RESEARCH LABORATORIES, INC.

ITEM NO	PART NO	DESCRIPTION	QTY

MATERIAL LIST

UNLESS OTHERWISE SPECIFIED
SCALE:
DIMENSIONS ARE IN INCHES
DECIMALS: ± .XX = ± .XXX =
ANGLES: ±
MACHINED SURFACES: √
DO NOT SCALE DRAWING
FINISH:

NEXT ASS'Y: 1121
REQ'D: 1
USED ON:

E-H RESEARCH LABORATORIES, INC.
OAKLAND, CALIFORNIA

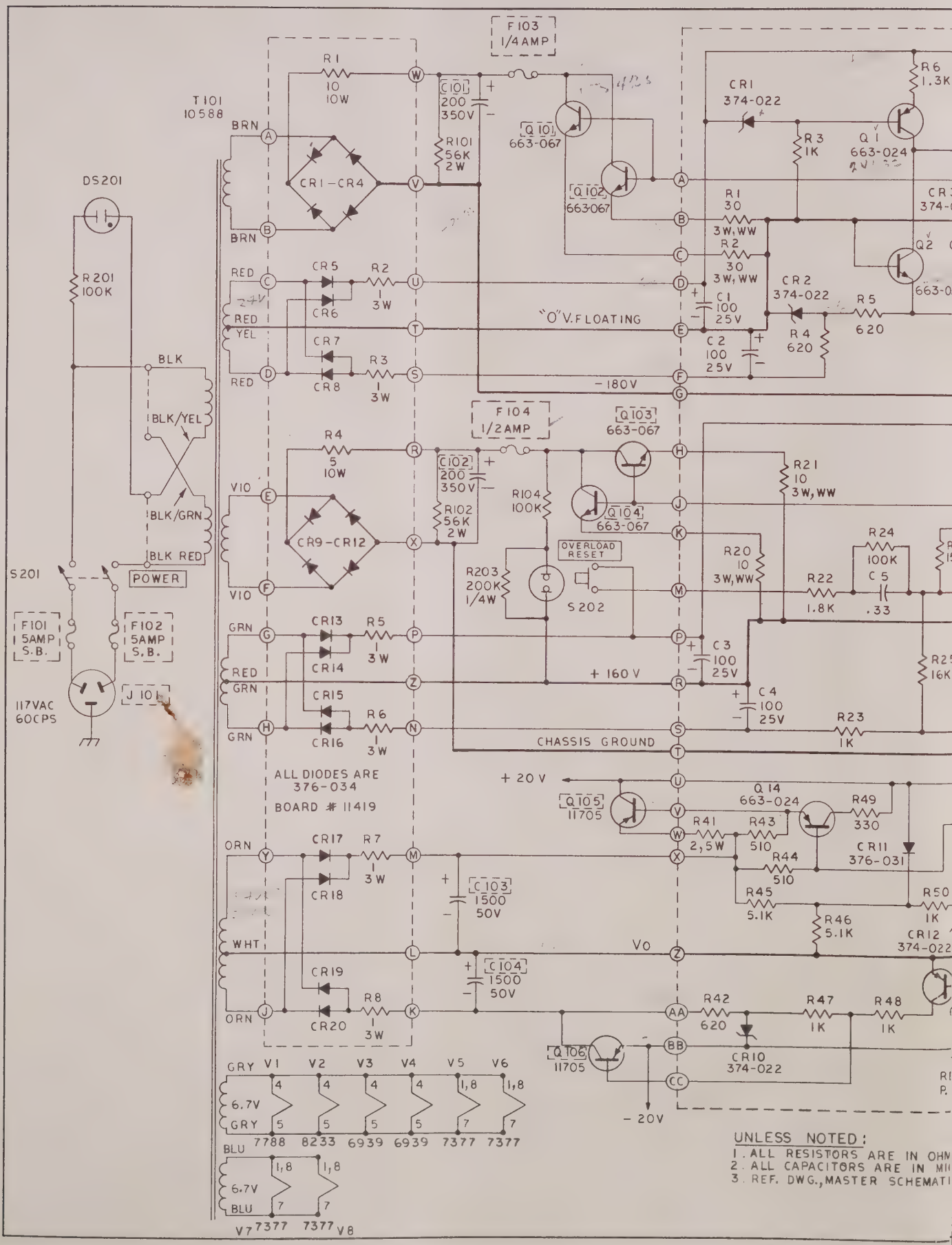
TITLE: ATTENUATOR SCHEMATIC

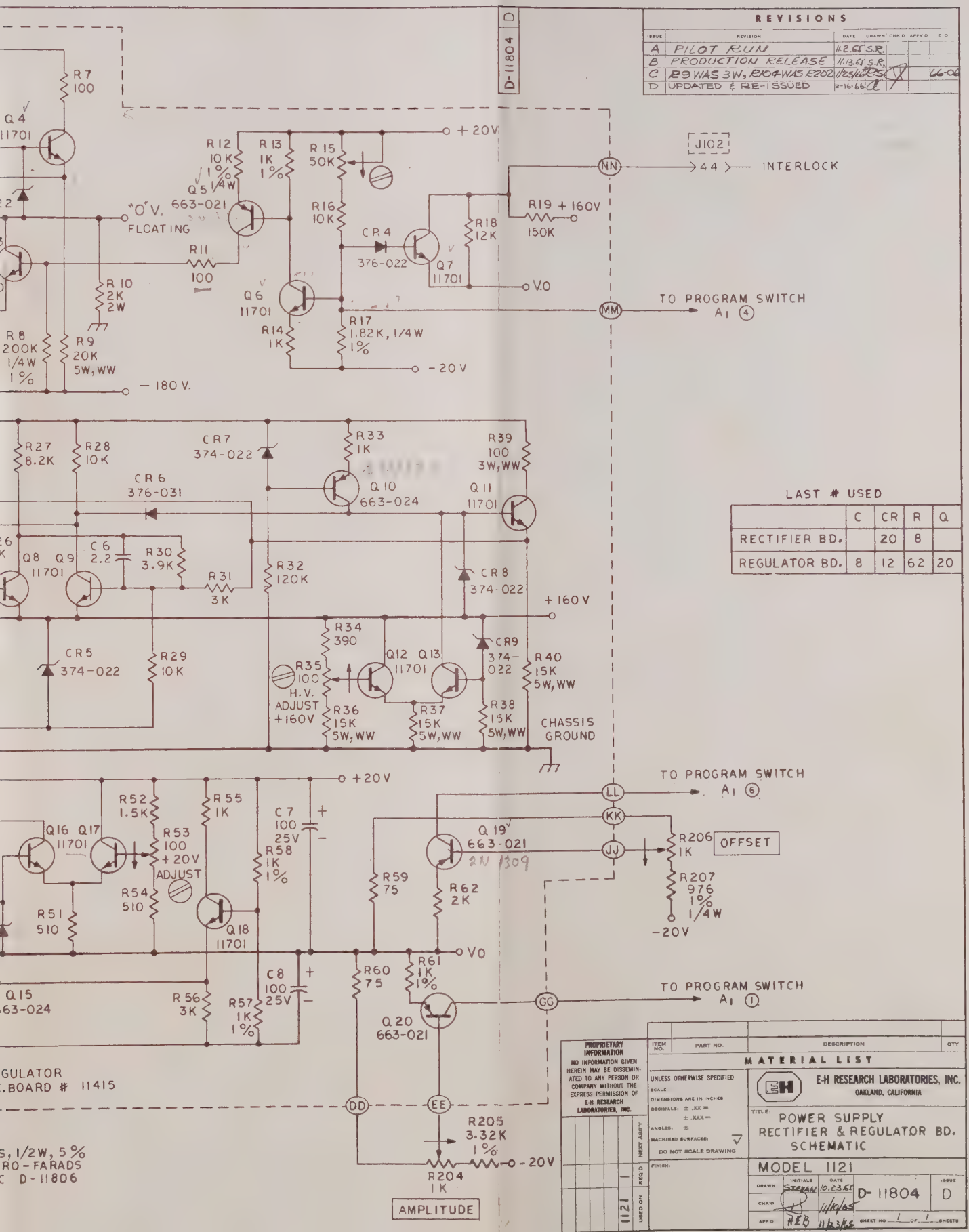
MODEL 1121

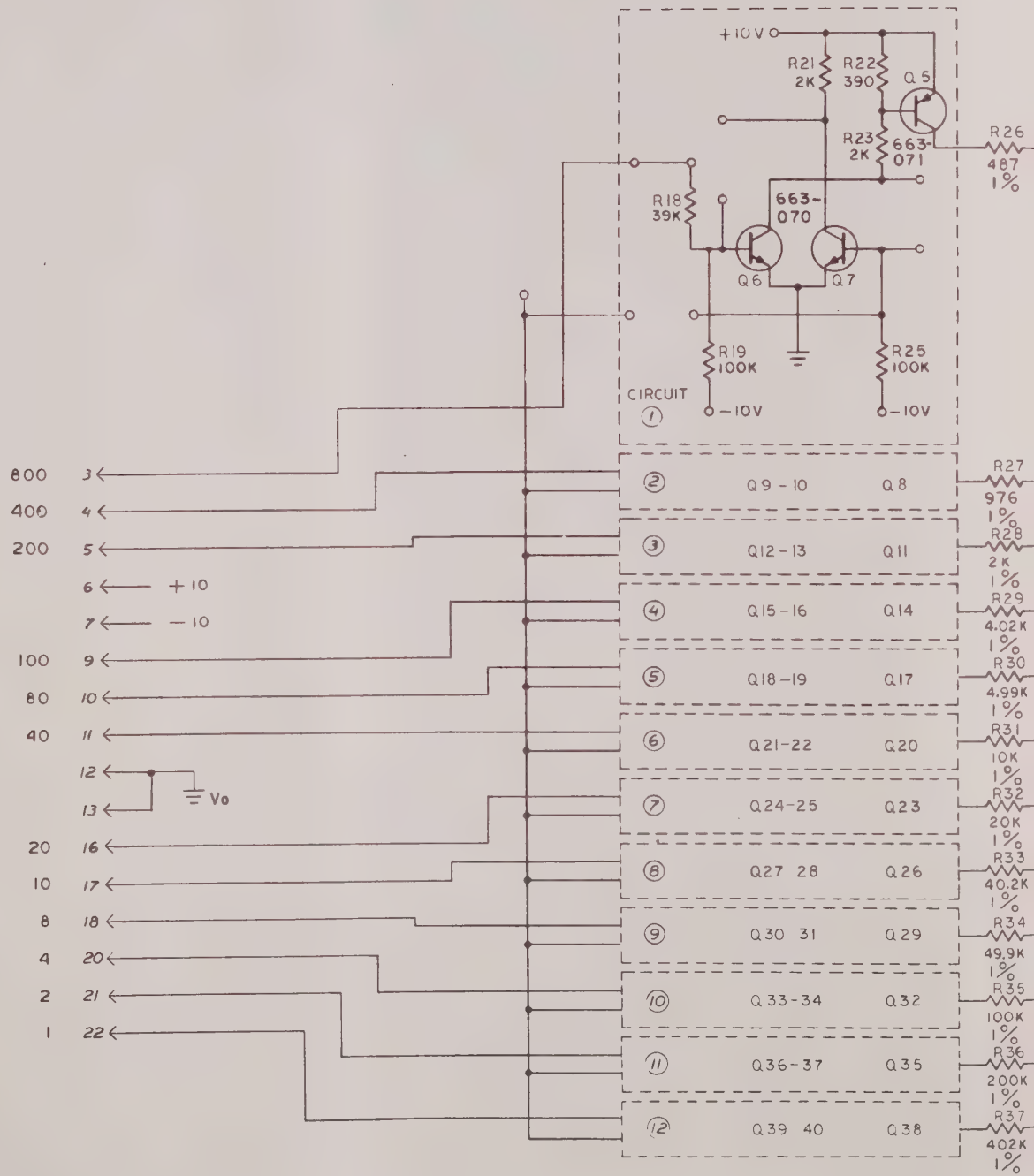
	INITIALS	DATE
DRAWN	STEMAN	11.9.65
CHK'D		11/10/65
APP'D		

D-11853 ISSUE B

SHEET NO. ___ OF ___ SHEETS

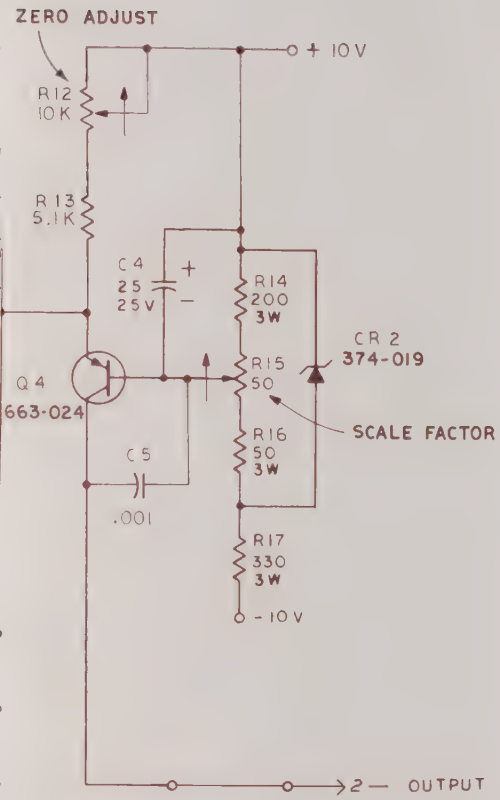

F103 1/4AMP
T101 10588
BRN
BRN
R1 10 10W
C101 200 350V
R101 56K 2W
CR1-CR4
Q101 663-067
Q102 663067
CR1 374-022
R3 1K
Q1 663-024
R6 1.3K
R1 30 3W, WW
R2 30 3W, WW
Q2
CR2 374-022
R5 620
R4 620
C1 100 25V
C2 100 25V
"O" V. FLOATING
-180V
DS201
R201 100K
BLK
BLK/YEL
BLK/GRN
BLK RED
S201
POWER
F101 5AMP S.B.
F102 5AMP S.B.
117VAC 60CPS
J101
RED
RED
YEL
RED
CR5
CR6
CR7
CR8
R2 3W
R3 3W
F104 1/2AMP
Q103 663-067
R4 5 10W
C102 200 350V
R102 56K 2W
R104 100K
Q104 663-067
VIO
VIO
CR9-CR12
OVERLOAD RESET
S202
R203 200K 1/4W
R21 10 3W, WW
R20 10 3W, WW
R24 100K
C5 .33
R22 1.8K
GRN
RED
GRN
GRN
CR13
CR14
CR15
CR16
R5 3W
R6 3W
+160V
C3 100 25V
C4 100 25V
R23 1K
CHASSIS GROUND
ALL DIODES ARE 376-034
BOARD # 11419
+20V
Q105 11705
Q14 663-024
R49 330
R41 2,5W
R43 510
R44 510
CR11 376-031
R45 5.1K
R46 5.1K
R50 1K
CR12 374-022
ORN
WHT
ORN
CR17
CR18
CR19
CR20
R7 3W
R8 3W
C103 1500 50V
C104 1500 50V
VO
R42 620
R47 1K
R48 1K
CR10 374-022
Q106 11705
-20V
GRY V1 V2 V3 V4 V5 V6
6.7V GRY
7788 8233 6939 6939 7377 7377
BLU
6.7V BLU
V7 7377 7377 V8
UNLESS NOTED:
1. ALL RESISTORS ARE IN OHM
2. ALL CAPACITORS ARE IN MI
3. REF. DWG., MASTER SCHEMATI


D-11804 D
REVISIONS
ISSUE | REVISION | DATE | DRAWN | CHK'D | APP'D
A PILOT RUN 11.2.65 S.R.
B PRODUCTION RELEASE 11.3.65 S.R.
C R9 WAS 3W, R104 WAS R202 11.25.65 R.P.S.
D UPDATED & RE-ISSUED 2-16-66
R7 100
Q4 11701
R12 10K 1% 1/4W
R13 1K 1%
R15 50K
+20V
J102
NN
44
INTERLOCK
Q5 663-021
"O" V. FLOATING
R16 10K
R19 +160V 150K
CR4 376-022
R18 12K
Q7 11701
V0
R11 100
R10 2K 2W
Q6 11701
R14 1K
R17 1.82K, 1/4W 1%
MM
TO PROGRAM SWITCH A1 (4)
R8 200K 1/4W 1%
R9 20K 5W, WW
-180 V.
-20V
R27 8.2K
R28 10K
CR7 374-022
R33 1K
R39 100 3W, WW
CR6 376-031
Q10 663-024
Q11 11701
C6 2.2
R30 3.9K
Q8 Q9 11701
R31 3K
R32 120K
CR8 374-022
+160V
R34 390
CR5 374-022
R29 10K
R35 100 H.V. ADJUST +160V
Q12 Q13 11701
CR9 374-022
R40 15K 5W, WW
R36 15K 5W, WW
R37 15K 5W, WW
R38 15K 5W, WW
CHASSIS GROUND
LAST # USED
C CR R Q
RECTIFIER BD. 20 8
REGULATOR BD. 8 12 62 20
+20V
R52 1.5K
R55 1K
C7 100 25V
Q16 Q17 11701
R53 100 +20V ADJUST
R58 1K 1%
R54 510
R51 510
Q18 11701
Q19 663-021 2N1309
R59 75
R62 2K
LL
KK
JJ
R206 1K OFFSET
R207 976 1% 1/4W
-20V
V0
C8 100 25V
R60 75
R61 1K 1%
R56 3K
R57 1K 1%
Q20 663-021
GG
TO PROGRAM SWITCH A1 (1)
Q15 663-024
GULATOR BOARD # 11415
DD
EE
R205 3.32K 1%
R204 1K
-20V
AMPLITUDE
S, 1/2W, 5%
RO-FARADS
C D-11806
PROPRIETARY INFORMATION
NO INFORMATION GIVEN HEREIN MAY BE DISSEMINATED TO ANY PERSON OR COMPANY WITHOUT THE EXPRESS PERMISSION OF E-H RESEARCH LABORATORIES, INC.
ITEM NO. | PART NO. | DESCRIPTION | QTY
MATERIAL LIST
UNLESS OTHERWISE SPECIFIED
SCALE
DIMENSIONS ARE IN INCHES
DECIMALS: ± .XX ± .XXX
ANGLES: ±
MACHINED SURFACES
DO NOT SCALE DRAWING
FINISH:
E-H RESEARCH LABORATORIES, INC.
OAKLAND, CALIFORNIA
TITLE: POWER SUPPLY RECTIFIER & REGULATOR BD. SCHEMATIC
MODEL 1121
DRAWN STEFAN 10.23.65
CHK'D 11/10/65
APP'D REB 11/23/65
D-11804 D
SHEET NO 1 OF 1 SHEETS
NEXT ASS'Y
REQ'D 1
USED ON 1121


+10V
R21 2K
R22 390
Q5
R23 2K
663-071
R26 487 1%
R18 39K
663-070
Q6
Q7
R19 100K
R25 100K
CIRCUIT (1)
-10V
-10V
800 3
400 4
200 5
6 ← +10
7 ← -10
100 9
80 10
40 11
12
13
Vo
20 16
10 17
8 18
4 20
2 21
1 22
(2) Q9-10 Q8 R27 976 1%
(3) Q12-13 Q11 R28 2K 1%
(4) Q15-16 Q14 R29 4.02K 1%
(5) Q18-19 Q17 R30 4.99K 1%
(6) Q21-22 Q20 R31 10K 1%
(7) Q24-25 Q23 R32 20K 1%
(8) Q27 28 Q26 R33 40.2K 1%
(9) Q30 31 Q29 R34 49.9K 1%
(10) Q33-34 Q32 R35 100K 1%
(11) Q36-37 Q35 R36 200K 1%
(12) Q39 40 Q38 R37 402K 1%

D-11502

REVISIONS					
ISSUE	REVISION	DATE	DRAWN	CHK'D	APPV'D
A	INITIAL RELEASE	7-27-65	S.R.		
B	PILOT RUN EVAL	12-7-65	S.R.		



UNLESS NOTED:

1. ALL RESISTORS ARE IN OHMS, 1/4W, 5%
2. ALL CAPACITORS ARE IN MICRO-FARADS
3. REF. DWG.,
   D-11854 ASSEMBLY
   B-11294 P. C. BOARD

PROPRIETARY INFORMATION
NO INFORMATION GIVEN HEREIN MAY BE DISSEMINATED TO ANY PERSON OR COMPANY WITHOUT THE EXPRESS PERMISSION OF E-H RESEARCH LABORATORIES, INC.

ITEM NO	PART NO	DESCRIPTION	QTY

MATERIAL LIST

UNLESS OTHERWISE SPECIFIED
SCALE
DIMENSIONS ARE IN INCHES
DECIMALS ± XX ± XXX
ANGLES ±
MACHINED SURFACES
DO NOT SCALE DRAWING
FINISH

E-H RESEARCH LABORATORIES, INC.
OAKLAND, CALIFORNIA

TITLE
DIGITAL TO ANALOG CONVERTER + DC

MODEL 930-1

	INITIALS	DATE
DRAWN	STEVEN	4.6.65
CHK'D	TLM	7-13-65
APP'D	R.Y.	2-25-66

D-11502 ISSUE B

SHEET NO 1 OF 1 SHEETS

NEXT ASSY	REQ'D	USED ON
	2	1421
		1121

SERVICE INFORMATION

ORDERING INFORMATION

Replacement parts may be ordered through your E-H Representative or from the factory. To be certain that you receive the proper replacement parts, always include the following information with your order:

a. Model Number and Serial Number of the instrument on which the replacement parts will be installed.

b. Circuit or Drawing Reference for which each part is intended.

c. E-H Part Number.

This instrument contains several factory-selected components to ensure optimum performance. In no case should a diode or transistor be replaced with one from a different manufacturer, unless it is on the specific recommendation of E-H.

When replacement parts are necessary, be sure to order through the E-H Customer Service organization. In this way, we can best serve you by providing up-to-date factory recommended parts and service information.

WARRANTY

This instrument is guaranteed to be free from defects in material and workmanship. Our obligation is limited to repairing the instrument should it prove to be defective, upon our examination, within one (1) year after the purchase date. Fuses and batteries are specifically excluded from warranty. Electron tubes, transistors, and diodes are warranted for six (6) months.

For In-Warranty repair of this instrument, contact E-H Research Laboratories, Inc., Customer Service Department, and provide:

a. Instrument Model Number and Serial Number.

b. Full details concerning the nature of the malfunction.

Shipping instructions, or repair information and parts, will be sent to you promptly.

CUSTOMER SERVICE DEPARTMENT, E-H RESEARCH LABORATORIES, INC.

163 ADELINE STREET, OAKLAND, CALIFORNIA - Phone: TE 4-3030, Area Code 415

CIRCUIT REFERENCE	DESCRIPTION	E-H PART NO.
TIMING P.C. BOARD		
C6, 10	Cap., 500pf	311-009
C2	Cap.,.1μf	311-014
C4, 7, 11, 12, 18	Cap.,.001μf	311-016
C3	Cap.,.05μf	311-021
C1, 16	Cap.,.01μf	311-012
C8, 13	Cap., 25μf/25v	316-028
C15	Cap., 50pf	311-006
C5, 9	Cap., 5600pf (Mucon)	311-047
CR31, 32	Diode, 1N753A (Matched)	11730
CR2, 4	Diode, 1N751A (Matched)	11731
CR6, 20-24	Diode, 1N914B	376-022
CR1, 3, 5, 7-9, 14, 35, 15, 16, 27-30, 33, 36	Diode, CGD1419	11742
CR19	Diode, 1N746	374-017
CR26	Diode, 1N270	376-031
CR25	Diode, RCA 40065	376-044
CR11, 12, 17, 18	Diode, FD777	376-059
L1	Choke, 1.5μh	335-001
L2, 4	Choke, .33μh	335-010
L3	Choke, .68μh	335-013
R19, 29	Resistor, 4.7Ω, 1/4W, 5%	595-047
R4	Resistor, 20Ω, 1/4W, 5%	595-200
R28, 68	Resistor, 47Ω, 1/4W, 5%	595-470
R48, 60	Resistor, 51Ω, 1/4W, 5%	595-510
R12, 37	Resistor, 100Ω, 1/4W, 5%	595-101
R41	Resistor, 120Ω, 1/4W, 5%	595-121
R18, 71	Resistor, 150Ω, 1/4W, 5%	595-151
R3	Resistor, 240Ω, 1/4W, 5%	595-241
R36	Resistor, 130Ω, 1/4W, 5%	595-131
R16, 61	Resistor, 200Ω, 1/4W, 5%	595-201
R5, 6, 51, 56, 58	Resistor, 220Ω, 1/4W, 5%	595-221
R23, 32	Resistor, 270Ω, 1/4W, 5%	595-271
R10	Resistor, 360Ω, 1/4W, 5%	595-361
R38	Resistor, 430Ω, 1/4W, 5%	595-431
R39, 40, 67, 72, 69	Resistor, 510Ω, 1/4W, 5%	595-511
R15	Resistor, 680Ω, 1/4W, 5%	595-681
R14, 63	Resistor, 750Ω, 1/4W, 5%	595-751
R57	Resistor, 820Ω, 1/4W, 5%	595-821
R2, 8, 20-22, 30, 54, 66, 31	Resistor, 1K, 1/4W, 5%	595-102
R46	Resistor, 1.2K, 1/4W, 5%	596-122
R55	Resistor, 1.3K, 1/4W, 5%	595-132
R7, 9, 70	Resistor, 1.5K, 1/4W, 5%	595-152
R49	Resistor, 1.8K, 1/4W, 5%	595-182
R11, 13, 59, 64	Resistor, 2K, 1/4W, 5%	595-202
R26	Resistor, 2.4K, 1/4W, 5%	595-242
R62, 65	Resistor, 3K, 1/4W, 5%	595-302
R1	Resistor, 6.2K, 1/4W, 5%	595-622
R24, 34, 52	Resistor, 10K, 1/4W, 5%	595-103
R42	Resistor, 10Ω, 1/4W, 5%	595-100
R50	Resistor, 75K, 1/4W, 5%	595-753
R43	Resistor, 36Ω, 1/4W, 5%	596-360
R44, 45	Resistor, 180Ω, 1/2W, 5%	596-181
R73	Resistor, 560Ω, 1/2W, 5%	596-561
R35	Resistor, 620Ω, 1/2W, 5%	596-621
R17, 27	Resistor, 191Ω, MF, 1/4W, 1%	617-020
R25, 33	Resistor, 499Ω, MF, 1/4W, 1%	617-005
Q4, 28, 29	Transistor, CDQ10239	11701
Q1, 8-10, 14-16, 27, 19, 20, 23, 24	Transistor, 2N2369	663-009
Q2, 3	Transistor, 2N706B	663-023
Q7, 13	Transistor, 2N1132	663-024
Q11, 12, 17, 18, 21, 22	Transistor, XF1367	11475
C14, 17	Cap., ceramic, 20pf	311-002
Q5, 6, 25, 26	Transistor, 2N966	663-032
CR10, 13, 34	Diode, Zener, 1N753	374-019
R47	Resistor, 1K, 1/2W, 5%	596-102
L5, 6	Choke	A10995
R53	Resistor, 820Ω, 1/2W, 5%	596-821
POWER SUPPLY REGULATOR P.C. BOARD		
C1-3	Cap., 100μf/25v	316-035
C4, 5	Cap., 25μf/10v	316-041
CR2, 4, 5	Diode, 1N751A	374-022
CR1, 3	Diode, 1N270	376-031
R10, 21	Pot., 100Ω, locking	545-035
R32, 34	Resistor, 75Ω, 1/4W, 5%	595-750
R6	Resistor, 330Ω, 1/2W, 5%	596-331
R11	Resistor, 430Ω, 1/2W, 5%	596-431
R2, 38, 14, 15, 19	Resistor, 510Ω, 1/2W, 5%	596-511
R23	Resistor, 620Ω, 1/2W, 5%	596-621
R7, 9, 17, 18, 24, 25, 27	Resistor, 1K, 1/2W, 5%	596-102
R26	Resistor, 3K, 1/2W, 5%	596-302
R4, 5, 13, 16	Resistor, 5.1K, 1/2W, 5%	596-512
R1, 12	Resistor, 2Ω, 5W, WW	610-018
R31, 33	Resistor, 499Ω, 1/4W, MF, 1%	617-005
R30	Resistor, 665Ω, 1/2W, MF, 1%	618-026
R28	Resistor, 931Ω, 1/2W, MF, 1%	618-009

CIRCUIT REFERENCE	DESCRIPTION	E-H PART NO.
Q2, 3, 5, 6, 8	Transistor, CDQ10239	11701
Q1, 4, 7	Transistor, 2N1303	663-011
Q9, 10	Transistor, 2N1309	663-021
R20, 22	Resistor, 560Ω, 1/2W, 5%	596-561
POWER SUPPLY CHASSIS		
C101, 102	Cap., 1500μf/50v	316-045
XA101, 102	Connector 22 pin (cinch)	743-001
R103, 105, 107	Pot., 50Ω	545-036
R101	Pot., 100Ω	545-035
R102	Pot., 2.5K	545-010
R104, 106	Pot., 50K	545-008
T101	Transformer	10582
Q101, 102, 103	Transistor	11705
CR101-104	Diode, 1N4005	376-034
R108, 109	Resistor, 1Ω, 5W, WW	610-002
CHASSIS AND PANEL COMPONENTS		
FRONT PANEL ASSEMBLY		
J201-203	BNC Connector	721-013
DS201	Lamp. Neon (Red) w/cup	510-008
R202	Pot., 5K	550-003
R209, 211	Pot., 10 turn, 1K, 3%	540-010
R201	Resistor, 100K, 1/2W, 5%	596-104
S203	Switch Deck, 5p, 2-3 pos.	624-053
S201	Switch, toggle, DPDT	630-006
R210, 212	Resistor, 1.87K, 1/2W, MF, 1%	618-017
S203	Switch, Index, 60°	624-052
FREQ. SWITCH ASSEMBLY		
S202	Switch, FREQ., Non-short	624-028
C203	Cap., .033μf, Mylar	320-029
C206	Cap., .33μf, Mylar	320-030
C204	Cap., .02μf, Mylar	320-022
C207	Cap., .2μf, Mylar	320-024
C202	Cap., .01μf, poly	326-006
C205	Cap., .1μf	320-007
C201	Cap., 2000pf, poly	326-012
C208	Cap., 1.0μf	320-011
C209	Cap., 1000pf, poly	326-005
C210	Cap., 2500pf, poly	326-011
R203	Resistor, 2K, 1/2W, 5%	596-202
MISCELLANEOUS		
	Delay Assembly	11632
	Handle, USECO, #1050-30	425-008
	Knob	443-009
	Dial, 10 turn	445-002
	D/A Converter (Model 930-1)	930-1
J101	A/C Connector	700-033

CIRCUIT REFERENCE	DESCRIPTION	E-H PART NO.
XF100, 102	Fuse Post	396-001
	Cover, Top	11493
	Cover, Bottom	11494
	Power Cord	786-001
F101, 102	Fuse, 1/2 amp, S.B.	398-009
J103	Connector, 50 Pin, Blu Rib	700-026
J102	Connector, Winchester MRAC-75S-J6	700-028
J102	Connector, Winchester Socket 100-1022/S	700-025
J102	Connector Bracket, MRAC75B	700-027
J104	Connector BNC	721-014

CIRCUIT REFERENCE	DESCRIPTION	E-H PART NO.
OFFSET P.C. BOARD		
R1	Pot., 10K (E-Z trim)	551-019
R4, 5	Pot., 100Ω (E-Z trim)	551-024
R18	Resistor, 2.2K, 1/2W, 5%	596-222
R14	Resistor, 470Ω, 1/2W, 5%	596-471
R7	Resistor, 430Ω, 1/2W, 5%	596-431
R17	Resistor, 680Ω, 1/2W, 5%	596-681
R8-11	Resistor, 750Ω, 1/2W, 5%	596-751
R15	Resistor, 2K, 1/2W, 5%	596-202
R16	Resistor, 20K, 1/2W, 5%	596-203
R2	Resistor, 30K, 1/2W, 5%	596-303
R12, 13	Resistor, 30Ω, 3W, 5%	610-067
Q1, 3, 5	Transistor, CDQ10239	11701
Q6	Transistor, PADT-50	663-005
Q4, 2	Transistor, 2N1132	663-024
Q7	Transistor, DTS-423	11726
R6	Resistor, 374Ω, 1/2W, 1%	618-028
R3	Resistor, 787Ω, 1/2W, 1%	618-030
OUTPUT P.C. BOARD		
K1	Bobbin Assembly Dual Reed	11873
T6	Balun Assembly, #1	11431
C13, 21, 22	Cap., .001μf, 1KV, 10%	311-010
C3, 6, 7, 12, 15, 27, 19, 23-26	Cap., .01μf, 20%	311-012
C2, 8, 10, 14, 16, 27	Cap., .1μf/500v	
C4, 18	Cap., 10μf/250v	316-002
C1, 5, 11	Cap., 25μf/25v	316-028
C20	Cap., 100μf/15v	316-030
L2	Choke, .22μh	335-014
L1, 3-5, 6, 7, 11	Choke, .68μh	335-013
L10	Choke, 10 turn	11652
L8	Choke, 8 turn	11874
L9	Choke, 6 turn	11653
CR3	Diode, 1N753	374-019
CR1, 4	Diode, 1N751A	374-022
CR5	Diode, 1N759A	374-037
CR2	Diode, 1N756A	374-064
	Reed Switch	584-005
R5, 9, 13, 17, 19	Resistor, 10Ω, 1/2W, 5%	596-100
R3, 7	Resistor, 15K, 5W, WW	610-080
R6	Resistor, 51Ω, 1W, 5%	597-510
R30	Resistor, 470Ω, 1W, 5%	597-471
R1, 2	Resistor, 51Ω, 1/2W, 5%	596-510
R15	Resistor, 22K, 1W, 5%	597-223
R11, 25	Resistor, 51K, 1W, 5%	597-513
R20, 21	Resistor, 51Ω, 2W, 5%	598-510
R4, 8, 12, 16	Resistor, 100Ω, 2W, 5%	598-101
R10, 14, 18, 22, 23, 26, 28, 29	Resistor, 130Ω, 2W, 5%	598-131
R27	Resistor, 620Ω, 1/2W, 5%	596-621
R24	Resistor, 39K, 2W, 5%	598-393
T1, 4, 5	Transformer Interstage, #1	11424
T2, 3	Transformer Interstage, #2	11426
Q1, 2	Transistor, 2N250	11705
C6	Cap., 2.2μf/25v, Mono	311-019
C1-4, 7, 8	Cap., 100μf/25v	316-035
C5	Cap., .33μf/25v, Mono	311-045
CR1-3, 5, 7-10, 12	Diode, 1N751A	374-022
CR4	Diode, 1N914B	376-022
CR11, 6	Diode, 1N270	376-031
R35, 53	Pot., 100Ω, locking	545-035
R15	Pot., 50K, locking	545-008
R59, 60	Resistor, 75Ω, 1/2W, 5%	596-750
R7, 11	Resistor, 100Ω, 1/2W, 5%	596-101
R49	Resistor, 330Ω, 1/2W, 5%	596-331
R34	Resistor, 390Ω, 1/2W, 5%	596-391
R43, 44, 54, 51	Resistor, 510Ω, 1/2W, 5%	596-511
R4, 5, 42	Resistor, 620Ω, 1/2W, 5%	596-621
R3, 14, 55, 50, 47, 48, 23, 33	Resistor, 1K, 1/2W, 5%	596-102
R6	Resistor, 1.3K, 1/2W, 5%	596-132
R42	Resistor, 1.5K, 1/2W, 5%	596-152
R22	Resistor, 1.8K, 1/2W, 5%	596-182
R62	Resistor, 2K, 1/2W, 5%	596-202
R31, 56	Resistor, 3K, 1/2W, 5%	596-302
R30	Resistor, 3.9K, 1/2W, 5%	596-392
R45, 46	Resistor, 5.1K, 1/2W, 5%	596-512
R27	Resistor, 8.2K, 1/2W, 5%	596-822
R29, 16, 28	Resistor, 10K, 1/2W, 5%	596-103
R18	Resistor, 12K, 1/2W, 5%	596-123
R24	Resistor, 100K, 1/2W, 5%	596-104
R32	Resistor, 120K, 1/2W, 5%	596-124
R26	Resistor, 15K, 1/2W, 5%	596-153
R19	Resistor, 150K, 1/2W, 5%	596-154
R25	Resistor, 16K, 1/2W, 5%	596-163
R20, 21	Resistor, 10Ω, 3W, WW	610-019
R1, 2	Resistor, 30Ω, 3W, WW	610-067
R39	Resistor, 100Ω, 3W, WW	610-060
R36-38, 40	Resistor, 15K, 5W, WW	610-080
R9	Resistor, 20K, 5W, WW	610-015
R17	Resistor, 1.82K, 1/4W, 1%	617-021
R57, 58, 61, 13	Resistor, 1K, 1/2W, MF, 1%	618-007
R12	Resistor, 10K, 1/4W, MF, 1%	617-019
R8	Resistor, 200K, 1/4W, MF, 1%	617-017
R10	Resistor, 2K, 2W, 5%	598-202

CIRCUIT REFERENCE	DESCRIPTION	E-H PART NO.
R41	Resistor, 2Ω, 5W, Sprague	610-018
Q19, 20, 5	Transistor, 2N1309	663-021
Q4, 6-9, 11-13, 16, 17, 18	Transistor, CDQ10239	11701
Q1, 10, 14, 15	Transistor, 2N1132	663-024
Q2, 3	Transistor, 2N1308	663-020
RECTIFIER P.C. BOARD		
CR1-20	Diode, 1N4005	376-034
R2, 3, 5, 6, 7, 8	Resistor, 1Ω, 3W, WW	610-069
R4	Resistor, 5Ω, 10W, WW	610-017
R1	Resistor, 10Ω, 10W, WW	610-016
RELAY DRIVER P.C. BOARD		
C1	Cap., 25μf/25v	316-028
CR1	Diode, 1N4005	376-034
R4	Resistor, 300Ω, 1/4W, 5%	595-301
R2	Resistor, 2K, 1/4W, 5%	595-202
R3	Resistor, 11K, 1/4W, 5%	595-113
Q1-8	Transistor, CDQ10239	11701
R1	Resistor, 400Ω, 3W, or 200Ω, 5W	610-072 610-084
FRONT PANEL ASSEMBLY		
DS201	Lamp Neon	510-008
R204, 206	Pot., 1K, 3%	540-010
R207	Resistor, 976Ω, 1/4W, 1%	617-009
R205	Resistor, 3.32K, 1/2W, MF, 1%	618-029
S203	Switch, 10 pol, 2-3 pos. (non-short)	624-051
S205	Switch, 3 pol, 12 pos. (shorting)	624-006
S204	Switch, 2 pol, 6 pos. (non-short)	624-004
S202	Switch, Pushbutton Clear	635-004
S201	Switch, toggle, DPDT	630-006
R203	Resistor, 200K, 1/4W, 5%	595-204
R201	Resistor, 100K, 1/2W, 5%	596-104
MAIN CHASSIS ASSEMBLY		
T102	Balun Assembly	11432
C101, 102	Cap., 200μf/350v	316-027
C103, 104	Cap., 1500μf/50v	316-045
XA101-103	Connector, 22 pin	743-001
CR101-105	Diode, 1N3020B	374-032
L101	Inductor	10783
L102	Inductor	10563
T101	Transformer	10588
Q105, 106	Transistor, 2N250	11705
	Attenuator Assembly	11363
R104	Resistor, 100K, 1/2W, 5%	596-104

CIRCUIT REFERENCE	DESCRIPTION	E-H PART NO.
R101-102	Resistor, 56K, 2W, 5%	598-563
R103	Resistor, 4.3K, 1/4W, 5%	595-432
MISCELLANEOUS		
	Counting Dial (helipot)	445-002
	Handle, Useco #1051-30	425-007
	Knob, K/K, 5-643-31	443-008
V5-8	Tube 7377	670-022
V1	Tube 7788	670-023
V2	Tube 8233	670-032
V3, 4	Tube 6939	670-025
C28	Cap., ceraminc .001μf	311-010
XF101, 2-4	Fuseholder	396-001
J101	Power Receptable	700-033
Q101-104	Transistor, DTS 423 Delco	11726
	Fan Grill	570-007
	Fan Motor	570-008
J102	Connector Amp 50	700-026
J103	Connector BNC	721-014
	Cover, Top	11637
	Cover, Bottom	11638
F101, 102	Fuse, 5 AMP, S.B.	398-015
F103	Fuse, 1/4 AMP, INST.	398-022
F104	Fuse, 1/2 AMP, INST.	398-021
	Power Cord	786-001
	Interconnect Cable (BNC)	11663
	Interconnect Cable (AMPH)	11664

SUMMARY... PULSE GENERATORS

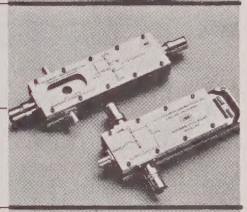
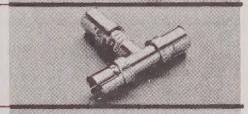
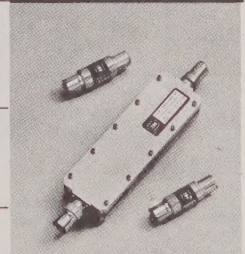
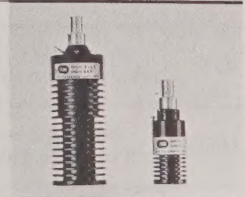
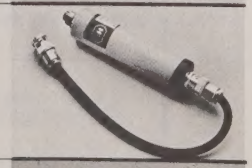
v=volts
a=amperes
Ω=ohms (omega)

Time abbreviations:
ps=picoseconds
ns=nanoseconds
μs=micro seconds
ms=milliseconds

MODEL	FEATURE	CLOCK	AMPLITUDE	RISETIME	WIDTH	DELAY	DUTY FACTOR	PRICE
120D	fast clean waveform at high rep rates	100 cps to 20 Mc	dual pulses −7 to −20v	<1.0ns at 10v <1.5ns at 20v	10 ns to 100 ns	fixed 100 ns	15% max	$1375
120E	same as Mod 120D, with attenuator	100 cps to 20 Mc	dual pulses −70mv to −20v	<1.3ns at 10v <1.5ns at 20v	10 ns to 100 ns	fixed 100 ns	10% max	$1675
121	1a into 50Ω at 5 ns	10 cps to 10 Mc	±5v to 50v	<5.0ns at 50v	30 ns to 1 μs	fixed 120 ns	20% max	$1675
122	rep rates to 200 Mc tr <1.0 ns	1 kc to 200 Mc	±150mv to 5v	<1.0ns at 5v	2 ns to 100 μs	2 ns to 100 μs	>40%	$2875
123A	1a into 50Ω at 50% duty factor	1 kc to 20 Mc	±200mv to 50v	<7.0 ns	20 ns to 300 μs	50 ns to 100 μs	>50%	$1775
125	clean 200 ps rise-time at 1 Mc	10 cps to 1 Mc	−10v fixed	<200 ps	<1 ns to 100 μs	100 ns to 100 μs	10% max	$2275
126	clean 400 ps edge, to 100v	40 cps to 300 cps	0v to ±100v	<400 ps	2/20/70/90ns internal lines	none	not applicable	Consult factory
130	double pulse output	10 cps to 2 Mc	500 ma or 50v	10 ns	150 ns to 50 ms	150 ns to 50 ms	50% max	$1175
131	1a into 50Ω at low cost	10 cps to 100 kc	±100mv to 50v	<10 ns	100 ns to 500 μs	−1 μs to 1 ms	10% at 50v 20% at 25v	$ 575
132A	1a into 50Ω at 3.5 Mc	5 cps to 3.5 Mc	±400mv to 50v	<12ns to 100 ns	100 ns to 10 ms	100 ns to 10 ms	25% at 50v 50% at 25v	$ 715
133A	1a into 50Ω variable linear ramp	1 kc to 5 Mc	±200mv to 50v	<10 ns to 10 μs	50 ns to 300 μs	75 ns to 100 μs	>50%	$2275
138	dual outputs both polarities	300 cps to 10 Mc	±75mv to 7.5v	<10 ns	50 ns to 1 ms	50 ns to 1 ms	>50%	$ 890
139B	versatile 10v ramp at 50 Mc rates	10 cps 50 Mc	±30mv to 10v	6 ns to 3 ms	10 ns to 10 ms	10 ns to 10 ms	>50%	$1275
171	digital xtal timing remote programming	100 cps to 5 Mc	±30mv to 10v	6 ns to 100 μs	100 ns to 9.98 ms	none	no restriction	$2875
1030	frame & p.s. for 3 ea. 1033 plug-ins	none, requires external clock	±20v to 50v	10 ns to 10 μs	dependent on external timing	dependent on external timing	>50%	$1150
1033	2 independent 1a outputs variable linear ramp							$2575
1121	50v at 2 ns, ±5v offset remote programming	none	±500mv to 50v	<2.0ns at 50v	1 μs max	dependent on external timing	10% max	$2925
5112	high voltage pulse amplifier	none	−150v −400v	<20ns at 150v <25ns at 400v	dependent on external timing	dependent on external timing	0.3% max	$2695

All prices F.O.B. Oakland, California
Prices and Technical Data subject to change without notice.

PULSE ACCESSORIES

	MODEL	FUNCTION	DESCRIPTION	PRICE	
GR SERIES	901	MARKER GENERATOR	A passive circuit designed to provide 1 ns markers for time-base calibration. 1% accuracy, requires fast pulse to activate. GR connectors.	$220	
	902	TUNNEL DIODE PULSER	Produces 450 mv pulse at less than 100 ps rise time from slower pulse or sine waveforms applied to input. —1 volt required to switch tunnel diode. BNC input, GR output.	$190	
	950	TRANSISTOR MOUNT	A 50 ohm transmission line mount for measurement of transistor switching times to the sub-nanosecond region. AC coupled output. BNC DC inputs, GR signal in and out.	$340	
	951	DIODE MOUNT	A 50 ohm transmission line mount for measurement of diode switching times to the sub-nanosecond region. BNC bias input, GR signal in and out.	$340	
	960	TAP-OFF	A 50 ohm transmission line sampling device. 100:1 pickoff ratio. No appreciable discontinuity introduced into 50 ohm systems to 3 Gc. GR connectors.	$90	
	970	DC RESTORER	Clamps baseline to ground to eliminate shift in AC coupled sub-nanosecond pulse systems. Peak input 20 volts. Approx. 10% attenuation. Specify pos. or neg. polarity-GR connectors.	$90	
	971	RISE TIME STANDARD	Produces fixed, repeatable rise times from fast pulse inputs. Made in std times of 5, 2, 1, 0.5, 0.2 nanosecond, ±10%. Printed circuit stability. GR connectors.	$170	
	972	PULSE TRANSFORMER	A fast inverting transformer for 50 ohm systems. Rise time better than 0.25 ns. GR connectors.	$90	
BNC SERIES	ZT	PULSE TRANSFORMER	Nanosecond transformers for impedance matching or inversion. Impedances 50, 93, 125, 185, 200 ohms. Any combination input to output with or without inversion. BNC connectors.	$35	
	DT	DC RESTORER	Clamp designed to eliminate baseline shift in AC-coupled nanosecond pulse systems. Peak input 20 volts. Approximately 10% attenuation. DTP for positive pulses, DTN for negative. BNC connectors.	$60	
	RT	RISE TIME INTEGRATOR	For repeatable, fixed, known times from fast pulse input. Standard models at 5, 10, 20, 50, 100 ns. Special times on request. 10% accuracy, 0.5 amp max. average. BNC connectors.	$35	
	ZL-3 ZL-15	TERMINATIONS	Three watt and fifteen watt terminations for 50 ohm pulse systems. DC resistance accurate to 1%. VSWR <1.25 at 100 Mc. Scope tap. BNC connectors.	$55 $75	
	TP-2 TP-5 TP-10	ATTENUATORS	High power fixed attenuators with 2:1, 5:1, 10:1 ratios. Division ratios accurate to 10%. 12 watts max. continuous dissipation. For 50 ohm input and output. VSWR <1.25 at 100 Mc. BNC connectors.	$95	
	SP-10	SINGLE PULSE TRIGGER	A battery-operated triggering device for single-pulsing all E-H pulsers. Supplies a fast-rise 10 volt spike of either polarity. With cable. BNC connectors.	$45	
	CX-5	CABLE SET	Two five-foot lengths of RG58A/U, 50 ohm cable with male BNC connectors.	$18	

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